Distance Education System : VIEW Classroom(Dissertation_全文)

AUTHOR(S):

Kagawa, Osami

Distance Education System: VIEW Classroom

Osami KAGAWA

December 1996

Abstract

Backgrounds of Distance Education System

Since technological innovation is advancing rapidly, higher specialty and leadership have been strongly requested. However, barriers of geographical and time distance still keep educationally motivated people away from the chances of higher education. Also we should never forget that many physically handicapped people who have much difficulty of pursuing latest knowledge.

Distance education is one of the efficient solutions for them. However, the medium which most of traditional distance education use widely such as prints, audio, video and broadcasting are insufficiency for interactive communication, and have requested improvement from tutors and learners.

Recently, computer assisted distance education systems are recognized as one of the comparatively new application domains deeply related with the remarkable development of multimedia, computer network and CSCW (Computer-Supported Cooperative Work) technology. They have had strong positive effects on computer-assisted teaching and learning styles and distance education environment. Those advanced technologies have enabled distance students enjoy colorful graphic materials and moving pictures making direct communication with a teacher and even share group work with other students in distributed locations.

Currently, due to the growth of Internet, many challenging distance education systems using E-mail and the WWW (World-Wide-Web) have appeared and started services crossing borders of nations. They have been taking effect for global wide and rapid communication, however, most of them only cover limited educational activities and focus on specific school subjects, besides communication is fundamentally asynchronous. To promote the diversity of

educational activities in classroom they are still short in powerful interaction supports, especially for dynamic teaching-learning process in lecture.

Objectives of VIEW Classroom

To meet the social backgrounds and requirements from educational organization as we have seen above, the author proposes an advanced distance education system called *VIEW Classroom* which presents powerful interactive communication environment for the people who want to acquire higher knowledge and skills. The main objectives of *VIEW Classroom* are as follows:

Firstly, *VIEW Classroom* has been designed with a view to dissolve the disadvantages of not only geographical distance but also "time distance". This system enables distributed participants to feel attending in same classroom (virtual classroom) and enjoy cooperative work such as notation of presented material, exercise, test, and discussion which are carried in traditional face-to-face classroom regularly. More specifically, the system serves the review facility that enables students who have attended after class to replay the lecture (only the overview, if necessary), take notes and even ask questions. Currently, time independence is supposed to be one of the most significant subjects to be implemented in distance education system.

Secondly, this system attempts to realize synchronous teaching and learning in through "one-to-many" communication. Although many computer-assisted education systems have developed, most of them should be addressed as asynchronous "one-to-one" communication actually and they are insufficient in interactive communication. For example, E-mail-based systems in which tutors or counselors are forced to answer for great number of mails after class. CAI (Computer-Assisted Instruction) systems are basically synchronous "one-to-one" and tutor is software which requests careful courseware development presuming students possible actions. For the reason of educational efficiency and flexibility, the author has designed synchronous communication environment in "one-to-many" where an human teacher offers most up-to-date information in flexible way, and students are free to submit questions at any time. There has been still very few models of distance education system on the assumption of synchronous "one-to-many" interaction.

Thirdly, *VIEW Classroom* tries to present symbolic representation to inform a teacher of individual student status and general view of the class in real time. This advantage of computer assistance could open way to symbolic data handling in many fields in education systems,

especially as to recognition of student status.

Fourthly, extended usage of database and effectiveness of cooperative system are examined in this distance education systems as well as network architectures.

Lastly, *VIEW Classroom* aims to construct highly and totally integrated educational environment in long run, through technological integration and definition of human role.

Scope of This Thesis

The objectives of this thesis are:

- to specify the requirements for advanced distance education systems (see Chapter 2)
- to present teaching and learning model of *VIEW Classroom* (see Chapter 3)
- to propose basic architectures to support the model (see Chapter 3)
- to propose following main facilities of *VIEW Classroom*. In this paper, (1), (2), (3) are focused.
  - (1) Presentation and notation using hypermedia (see Chapter 4)
  - (2) Symbolic representation for student's status and succeeded interactive communication (see Chapter 5)
  - (3) Submission of a question by student and extracting valuable questions and prompt answering by teacher (see Chapter 6)
  - (4) Replay of lecture and asynchronous interaction for after class attendants
  - (5) Test executed in class
  - (6) Assessment of assignment
  - (7) Management of classroom administration
  - (8) System management

Main Facilities of VIEW Classroom

Chapter 4 describes presentation and notation facilities using hypermedia which utilizes distributed object-oriented database and CSCW technology. In *VIEW Classroom* , educational materials are mainly presented as hypermedia documents by a hypermedia system called *VIEW Media*. In lecture teacher and students can use identical screen contents on shared window (Media Sharing). Specific points unlike other hypermedia system are the flexibility. That is, students are allow to change links and organize personal environment of their own. So, they can

link teaching material with their notebook generated in database or modify the screen view by changing the window size as well as character size. Teacher also can modify teaching material even in lecture and the transaction is sent to students to update the materials. However, modification by student is managed so as to protect the original (Virtual Update). The teacher's private documents like administrative information as well as student notebooks are referred on each personalized windows (Personalization). The lecture process of is automatically recorded for giving a revival-lecture to the attendants after class. The record also helps a teacher to improve their teaching materials and methods.

Chapter 5 and 6 are both based on synchronous and asynchronous model presented in *VIEW Classroom*. This model forms the specific feature of this system Chapter 5 addresses on the facilities for symbolic representation of student's status and interactive communication. In class, a teacher of expert is checking students' faces and behaviors habitually, and changes the topics or the order of scenario flexibly, and often leads students to pose questions. In distance education with potential large attendants, however, it is impossible to present all the images of attendants on a display at the same time. Other mechanisms must be supported for the recognition of students. In *VIEW Classroom,* student status is collected and presented to the teacher time after time being summarized and processed into a specific colored symbol as the representative for a student. This function enables a teacher to catch the visual overview of students' status, showing the student-seat-map turning reddish (e.g. meaning "hard to understand") or bluish (e.g. meaning "very few responses").

In higher education, synchronous interaction plays most essential role. Leading students to appeal their opinions or to present the results of group discussion for other classmates need high-quality developed interaction support. However, once implemented, it surely decreases the disadvantage of one-way channel in traditional distance education. To communicate with a specific student, a teacher wishes to select most relevant partner among many distributed attendants. *VIEW Classroom* helps the teacher to pick up candidates provided by student-history-database within the long term information such as test results, attendance, profile, and short period information of that day. Combination use of student symbolic representation and access to a representative student is effective for interactive communication and student's site analysis.

Chapter 6 explains question and answer facilities. Most fundamental interaction between a

teacher and a student is questions and answers. It's quite desirable and natural style that a student poses a question when she/he just has a doubt independent from teachers situation. On the other hand, a teacher should catch students' unsatisfactory responses quickly, and dissolve the problems as soon as possible. Although, in a distance education system with many attendants, there exist many issues with student questions, for example, excessive concentration of questions, duplication of contents, indistinctness of importance, vagueness of contents or expression, and others.

Answering those issues as to question and answer, *VIEW Classroom* proposes following three facilities:

(1) Question-submission support facility for a student: Student may specify a keyphrase and the location (figure and picture included) on teaching material, and question sentence as a target of question. Then a relevant question-menu is shown proposing to select similar question if presented or to type in new question contents.

(2) Question-selection support facility for a teacher: Questions are classified with the similarity, and listed with the number of questioners. This function promotes teachers' easy selection and speedy answering. Moreover, if the teacher has set a weight on important key in teaching materials previously, the question related with the key word have a higher priority on question list. This suggests the strategic question selection is possible since the teacher can lead questions she/he wants.

(3) Answering support facility for a teacher: If more detail about a question needed, a teacher may ask the questioner in class directly. Since all the process of answering is broadcasted to other attendants, the answers to similar questions shall be almost settled. And also the process are stored for attendants after class to hear the questions and answers. Commonly, a teacher is charged of a few classes in a session, therefor similar questions are likely to be asked repeatedly in every class. *VIEW Classroom* supports "Automatic Answering" using Question-Answer database. If the system recognizes that there exists similar question in the database, it quickly answers on the spot. This service offers vital teaching-learning environment where students may have courage of asking questions, and a teacher may grasp the students' interest and level of understanding in real time. Therefore the feedback to the lecture might be taken rapidly.

Issues and future work

In Chapter 7, following topics are discussed and shown some ideas for the future work.

(1) Enhancement of Synchronous and Asynchronous Interaction Model

(2) Question-Answer Facility in After Class

(3) Symbolic Representation for Mass Education

(4) Pedagogy for Higher Education

(5) Intellectual, Phycological, Cultural Distance

Goal of VIEW Classroom

For initial design of the distance education system, the author studied on the analysis of traditional face-to-face classrooms based on the past experience of constructing an intelligent classroom using LAN (Local Area Network) (see Section 1.3). Through the analyses and discussions on the essential qualities of requirements, the author has found that what requested for a distance education system is to make the impossible activities in a physical classroom into possible, and create a new educational environment where geographic and time distance are not always fatal disadvantages. Moreover, wherever interactive teaching-learning style is requested, the core of this system should be available. Therefor, it might be said that the goal of *VIEW Classroom* is to built a new education environment without asking or stressing on the differences between real and virtual classroom.

VIEW Projects

VIEW Classroom is one of *VIEW* (Virtual Interactive Environment for Workgroup) projects which have being developed in Kambayashi Laboratory at Kyoto University. *The VIEW* projects are composed of *VIEW Media, VIEW Office, VIEW Conference* and *VIEW Classroom*. These are based on the object-oriented paradigm and advanced database management system with collaborative work. *VIEW Classroom* is now on design phase and shifting to prototyping and implementation partly.

Acknowledgments

This dissertation have been made possible through many people. I would like to express my deepest gratitude to Professors in Kyoto University. Most of all, my supervisor Yahiko Kambayashi of the department head of information science presented me initial guidance and insightful suggestions on advanced data base architecture. Without his support, this paper would not be possible since his ideas have built the backbone of this education system. Professor Shuzo Yajima, the head of Education Center, suggested me to take the theme: "distance education system" as my study subject. Associate Professor Shoichi Yokota gave me the big clues on database model in teaching-learning environment. Dr. Shin'ichi Konomi not only answer my specific requirement on hypermedia: *VIEW Media* but also helped me in designing of *VIEW Classroom*.

And more, I must thank Professor Subieta Kazimierz for many advice, and Associate Professor Werner Winiwarter from Vienna University who enhanced the Question and Answer facility through natural language interface. I am very grateful for their support.

It is not possible to mention all, but I am attempt to do at least: members of VIEW Project; Sang-Hoon Lee, Kazuya Sakata, Zhi Yong Peng, Kaoru Katayama, Yusuke Yokota, Yasuhiro Kamiya and Hiroyuki Imai for enthusiastic discussion. Especially I owe Kaoru Katayama, starting partner of *VIEW Classroom* for initial work.

At Hiroshima Denki Institute of Technology, I am grateful the chairman of directors Goroh Nishimoto, president Kaizou Kuwabara and director Takayuki Kubota for offering me the opportunities of studying in Kyoto. One paper on "satellite communication" have been written under joint authorship with my colleague Professor Kazuyoshi Miyoshi and Dr. Hisayuki Masui from MITSUBISHI Electric Corporation. Special thanks go to staffs of Information Processing Center for all burden after my quit.

Lastly, I must mention special thanks to Dr. Hazime Narumi Professor Emeritus of Hiroshima University for directing me to study in Kyoto University and suggesting academic discipline. It is my great pleasure if this thesis is taken for the celebration of his happy 77th birthday. Special thanks are also due to my wife Yu Kagawa for the edition of this thesis.

Contents

Distance Education System:
VIEW Classroom

Chapter 1

Introduction

This chapter presents an overview of distance education to have the common concept referring present status and the issues. Then the author describes the design motivation of advanced distance education system : *VIEW Classroom*. This is followed by an overview of the main facilities of the system.

1.1 Backgrounds of Distance Education System

To start with we should have an overview of traditional distance education so as to understand the specific features of *VIEW Classroom*.

Characteristics of distance education

With the characteristics of distance education, Keegan [Kee86] defines as follows:

- the separation of teacher and learner
- planning and preparation of learning materials by an educational organization
- use of media to carry course content and to unite teacher and student
- some form of two way communication
- student learning as individuals

Last item is a principal, however, another extended style could be included. That is "student learning as a group in (virtual) class " which has been possible by CSCW (Computer-Supported Cooperative Work) and network technology which have adopted to *VIEW Classroom*.

Currently, a term "distance learning" is often used, however, the difference is not so clear. The United States Distance Learning Association (USDLA) defines distance learning as "the acquisition of knowledge and skills through mediated information and instruction,

encompassing all technologies and other forms of learning at a distance".

Roles of distance education

Mostly, distance education started as one of the relief measures for children in depopulated area for the reason of educational equality. However, the role at present seems to be changing adding following reasons.

(1) financial shortage in enlargement educational facilities

(2) adaptation to enhancement and diversity of fundamental education

(3) needs from specialists for speedy learning of leading-edge technology or those who want credits toward a degree.

(4) new relief measures for poor family children or handicapped people who are abandoned from computer infrastructure

(5) adoption to a industrial or college management strategy

(6) extension of lifelong education

VIEW Classroom focuses on the attempt of (3) for initial stage. Therefore, the target students for the moment shall be students in undergraduate and postgraduate students, researchers, and businessmen just because they have the needs of specialized education. Educational objectives or subjects are not asked.

Generations of distance education

With the generation of distance education, Nipper divides into following three generations [Nip89].

- **1st generation**: Traditional correspondence model in which print is sole medium for communication.
- **2nd generation**: Industrialized multimedia is used, being integrated print and other modern media such as audio and video, computers, and broadcast into study package. In this generation, production and distribution of learning material is major objectives.
- **3rd generation**: Computer-assisted interactive communication is introduced.

The current systems of 3rd generation seem to be classified into following three phases according to communication level.

- E-mail-based system where E-mail plays a role of a substitute of communication in traditional education. Many existing systems belong to this phase.

- Integrated system of E-mail and WWW (World-Wide Web) which serves global distance learning. Currently, this kind of system is in fashion.
- Interactive communication environment system partly or totally supporting activities in classroom and campus, and integrating some of the technologies such as advanced database, CSCW/CSCL, artificial intelligence, virtual reality, satellite communication and so on. There are some systems in use, however, most of them are experimental.

VIEW Classroom belongs to 3rd generation supporting synchronous communication environment with CSCW technology.

1.2 Present Status and Issues

Currently distance education systems are full of variety in styles since those in each generations as we have seen previously are all alive. Therefore, we should focus on the distance education in 3rd generation from now on. In this section, technological backgrounds, global distance education system examples, and problems of distance education systems are described.

Present Status

Development of new media and network technology

New media have greatly contributed to education. Adding to traditional media such as broadcasting (radio, TV), audio/video tapes , and comparatively new media Fax, Videotex, and computer digital text are commonly used. Recently CAI (Computer-Assisted instruction-based systems have been advanced, and on-line CAI connected with host computer, ICAI (Intelligent Computer-Assisted instruction) introduced artificial intelligence have been provided.

Above all, due to the advanced computer network technology, E-mail and WWW are commonly introduced to distance education systems [GO96] [Reb96]. Internet provides a medium to transfer the teaching materials to different site and with the WWW browsers user can study in different environment at any time.

Moreover, since necessity of synchronous communication is stressed in recent years, satellite and computer-mediated communication are earning much attention. Those technology have implemented in some distance education systems supposing they could cover the geographical and time disadvantage.

Integration video and hypermedia

Currently, there seems to be two big flows: video-based and hypermedia-based. Former is still main flow in practice use. "Satellite Classroom" or "Video Conferencing Classroom" [JM96] might be referred as advanced models. Recently, some systems [AGZ96] are challenging to "total digitalization" using ATM (Asynchronous Transfer Mode) and ISDN (Integrated Services Digital Network).

Advancement of educational technology

With respect to theoretical aspect, "Educational Technology" [Sak91] must be addressed. That is one of the educational domains and has made rapid progress attended with new media. It deals with systematic educational study on analysis of educational objectives, design of teaching and learning style and method, use and verification of new media, examine structures and functions of academic facilities, the influences to learners, for example. Those results have undoubtedly contributed to implementation of computer-assisted distributed environment.

Trend of academic society on computer and education

Distance education have been paid much attention in the field of computer-assisted education system. For example, at the latest international conference on computer and education (ED-MEDIA/ED-TELECOM'96, Boston, 1996), distance education have three sessions of "Design of Distance Education", "Distance Education and Telelearning", "Distributed Learning Environments", where 64 papers from 16 countries were presented. And other 4 sessions out of 23 at least are tightly connected with distance education. Main topics were E-mail or the WWW-based learning systems. Trough those presentations, the author found that the systems presented by Japanese are tend to put stress on technical aspects of computer facilities, on the other hand, those by other countries are mostly based on educational trials and the results by educational professionals. Those presentations suggested that many distance education system or distributed learning systems are in use [AGZ96] [FF96] [GO96] [Reb96] or in planning stage [PBH96] throughout the world.

Examples of distance education system

Here, three distance education systems are shown. Those are nation wide or world wide systems started 1960s, 1980s, and 1990s, respectively.

The Open University (United Kingdom) : "The Open University" is the United Kingdom's distance teaching organization started in 1969. It has long history and is one of the largest-scale

organization in number of students, possessing 11 of colleges and graduate schools, and offers materials by post, via BBC (British Broadcasting Corporation) broadcasting programs or via computer networks. It is open to adults in UK or other member states of the European Union, and enables students to get qualifications awarded. Currently, more than 218,000 students are studying, and more than two million people have studied with Open University. Many educational experiments and studies to improve the system have been done year after year. (cf. WWW home page http://www.open.ac.uk/)

The University of the Air (Japan) : "The University of the Air" began broadcast lectures in 1985. People of 18 years and up are allow to enter this university with no entrance examinations. Elective courses are counted more than 300, and students are about 62,000 at the first session in 1996. More than 8,300 students have graduated so far. Mutual credit transfer is agreed with 95 colleges, universities and junior colleges. As of today, students in Kanto district enjoy broadcast lectures on TV (UHF) and radio (FM) from 6:00 in the morning until 12:00 midnight, and in other districts they can attend at 31 regional study centers as scheduled or can be offered a print textbook, audio or video cassette tapes to study at home. This system large-scale 2nd generation type. In near future, all lectures are to be on air through the country and there seems to widen this system to all Asia and the world, cooperating with other open university systems. (refer the guide book of the University of the Air)

Free University of Berlin (Federal Republic of Germany) : Comprising over 5,000 students, the department of economics at the Free University of Berlin is one of the largest in the Federal Republic of Germany. Three large universities, several research and educational establishments with over 100,000 students. Many students attend classes offered at other institutions if they were locally accessible. Many teachers offer joint lectures in cooperation with colleagues at other institutions preferably at no travel costs [AGZ96]. For this purpose an experimental broadband communication network was established in 1995. Students can access through the network digital learning material at various places. At a later date, private homes could be also connected to the broadband network.

Distance education service on WWW

Due to the extension of WWW, we can get distance education menu on WWW home page and select courses sponsored by colleges and universities in the world. For example, Globewide Network Academy is sponsored by almost 300 academic organizations in the world, and certain university offers more than 350 courses. Another example is that United States Distance

Learning Association serve fundamental education, higher education, continuing education, corporate training, and military and government training, including all fifty states in USA. This trend was far beyond our imagination before WWW has appeared.

Formal recognition of distance education in Japan

In Japan, formal recognition have not obtained for long period, however, Ministry of Education have undertaken educational system reformation and decided in July, 1996 that the 30 credits per a student obtained in distance learning at colleges and universities are acceptable, allowing the mutual credit transfer. This reformation is to be enforced in 1997, and now 24 universities and more than 400 subjects are starting this experiment since autumn 1996. In near future, this system is to be adapted to workers in business.

Issues of Current Distance Education Systems

(1) Insufficiency of interactive communication

Due to the wide availability of personal computers, computer-assisted learning has become increasingly attractive. Nevertheless in some current systems have the possibility of being abandoned from students . It suggest that even in fairly blessed environment, if there is few chances for student to take part in the learning activities or no direct responses from student to teacher are acknowledged, facilities might be in vain. Synchronous communication by not only voice but also computer-mediated communication environment is necessary.

(2) Difficulty of recognition of large attendants

For the nature of distance education, a teacher is likely to give a lecture without recognition of student's responses. The major reason is that teacher has a few or no means to obtain students' situation in real time. System should support collection and presentation of students' requests and situation and also help teacher to decrease the burden of their processing flood of transaction from students.

(3) Necessity of more interactive multimedia tools

Multimedia applications play important role in distance education, however, a lot of technical problems remain unsolved. Most essential key in designing is flexibility. If a valuable information is given or mistake is indicated by students, teaching material should be updated or modified even in lecture time.

(4) Delay of feedback for students, educational materials, and system

Lack or delay of feedback becomes fault in education system. It makes students isolate and decrease their motivation of learning and also makes teachers to leave their teaching materials untouched after lecture. Sill less system has never been improved. System should provide users with practical mechanisms to take speedy feedback actions.

(5) Lack of measures for time difference

Majority of students are supposed to have lectures after work. The time difference should be also considered in case of teachers and students are distributed all over the world.

1.3 Motivation

Mostly, major enterprises have developed strategic information or manufacturing systems of their own to support the growth of their business and get much advantages to other competitors. They analyze their working process from top management to details of works and try to build total supporting system creating a new strategy.

Moving from computer software maker to a college, the author has deeply impressed the lack of computer-based approach in education and the necessity of developing totally supported education system including teaching-learning activities and college management.

There are two types in education system. One is related with developing teaching materials and method like authoring tool and CAI tool which is used by teachers. Another is total support system targeting all the activities in academic organization. Those mostly include management, however, keep away from participation in each subject's teaching method or material.

In either case it seems to distinctively differ from competitive systems in other world. As the results, the cultural gap between educational world and others on recognition of computer assistance have widen year after year. Additionally, since extension of network infrastructure and development of computer capability have brought the merit to home facilities, the gap between classroom and home will also widen in near future. As matter of course, the author never insist the total computerization of campus life, however, classroom environment should not be isolated from other information sources since education environment should be open and connected with industrial, business, and others directly or indirectly.

Since distance education has inherited many issues from traditional classroom, solutions to those issues including the architectures and technology provided from distance education

system have much possibilities of adopting to traditional classroom. In that sense, the author believes that the development of advanced distance education system and the implementing which might create new teaching and learning environment and contribute to enhance the level of individual's ability and level of technology is very significant.

1.4 Requirements

This section addresses requirements for advanced distance education systems briefly to browse next section of overview of *VIEW Classroom*. The detail is described following chapter.

Variety of lecture styles

The actions in classroom is full of variety. Presentation and the notation is not always main style. Discussion, test, group work are useful to exchange knowledge and have good motivation for learning. Teacher, on the other hand, may have her/his own teaching methods. Therefore, the implementation model must be flexible so as to meet the teachers' and students' varying requirements.

Synchronous interaction

Jones [Jon96] requests distance education systems following support for:

- a student to follow the instructions.
- a student not to be isolated in a group activity.
- a student to know the other students' responses
- a student to ask questions at any time.

These requests are very fundamental requests for one-to-many style education also. However, his viewpoint is lack in teacher's standpoint, so I would like to add following requests.

- a teacher to recognize the students' response.
- a teacher to know questions have been submitted.

Recognition

Related with the topics above recognition becomes more significant to support in large class. Many distance education systems utilizing computer networks are based on window-share applications and video technology like conference systems. In those systems a teacher can see and confirm the response of each student and status of the whole class to some extent. In a computerized distance education system, however, because of the possibility of large

attendants, it is usually impossible for the teacher to present all students' faces on a display at the same time. Thus the teacher needs some non-video-based tools for collecting the responses of all students in real time, displaying in effective way, and picking up a student as a partner for conversation for example. Also, student should be noticed the existence of other students and their status to communicate with them.

Learner's view

Traditional presentation on screen is fixed with the window layout, character size, and others. Users prefer to modify them as they like, and also arrange or adjust the function or field offered by the system to their own environment.

Flexible multimedia application

System should serve multimedia and its applications such as Hypermedia. Linking a teaching materials with students notebook and changing link destination to existing documents will help students to copy the contents and create their own notebook.

Group learning environment

Cooperative teaching-learning architecture is now essential aspect , since in higher education discussion and other group works are basic activities in classroom. Problem of recognition or awareness is one of this field. Therefore, synchronous teaching-learning and discussion based on CSCW (Computer-Supported Cooperative Work) and CSCL (Computer-Supported Collaborative Learning) to teaching and learning process, a learner is never abandoned from a teacher in distant location. I this field discussion support system [IT94].

Strategic teaching environment

To select a student or divide students into some groups, teacher need some information to evaluate them. Not only administrative information but also the achievement information of that day like notation, question, and exercise should be available. Combination of those information helps teacher to make effective interaction with relevant student.

Control of student learning pace

Unlike CAI, learning pace is controlled by teacher. This could be demerit of instruction by human teacher in distance education. Therefore, reasonable pacing mechanism should be provided.

1.5 Overview of *VIEW Classroom*

VIEW projects

VIEW Classroom is one of *VIEW* (Virtual Interactive Environment for Workgroup) projects which have being developed in Kambayashi Laboratory at Kyoto University. *The VIEW* projects are composed of *VIEW Media, VIEW Office, VIEW Conference* and *VIEW Classroom.* These are based on the object-oriented paradigm and advanced database management system with collaborative work.

Figure 1.1 illustrates the conceptual image of *VIEW Classroom* where a teacher and students in distributed location are supposed to be in virtual classroom connected via network. Student can not only attend at real-time class as scheduled but also participate after the class by tracing the process of the lecture. Therefore, as time goes by, attended members are changeable. To support this environment, *VIEW Classroom* presents following facilities at present stage.

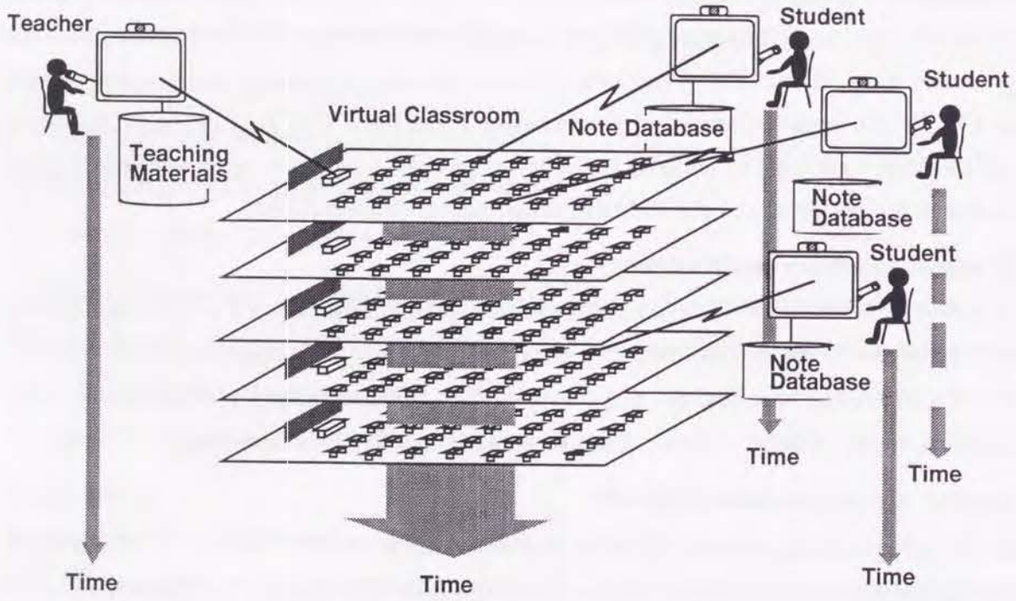

Figure 1.1 Image of VIEW Classroom

Presentation facility and notation facility

In *VIEW Classroom*, educational materials are mainly presented as hypermedia documents to the students within CSCW environment. A teacher can give a lecture, pointing and underlining on the text, figures, and images on shared windows, also using literatures from digital library presented on network. If necessary, the teacher can modify her/his teaching materials on the spot. The flexibility of modifying materials in class is significant for up-to-date and correct information.

While, a student can make her/his own notebook (note database), underlining, adding personal comments, linking with their own documents. These actions seem to cause update the teaching materials visually, however, originals are protected. Note that the modification by the teacher causes real update and can reflect on student notebooks. The teacher's private documents such as test results, student profiles as well as student notebooks and their questions are able to refer on each personalized area. Hypermedia *VIEW Media* implements these "Media Sharing", "Virtual Update", and "Personalization" utilizing advanced database functions. The process of the lecture is automatically recorded for giving a revival-lecture to the attendants after class. The record helps a teacher to improve their teaching materials and methods.

Symbolic representation facility and interactive communication facility

In class, a teacher of expert is checking students' faces and behaviors habitually, and changes the topics or the order of scenario flexibly, and often leads students to pose questions. In distance education with potential large attendants, however, it is impossible to present all the images of attendants on a display at the same time. Other mechanisms must be supported for the recognition of students. In *VIEW Classroom,* student status is collected and presented to the teacher time after time being summarized and processed into a specific colored symbol as the representative for a student. This function enables a teacher to catch the visual overview of students' status, showing the student-seat-map turning reddish (e.g. meaning "hard to understand") or bluish (e.g. meaning "very few responses").

In higher education, synchronous interaction plays most essential role. Leading students to appeal their opinions or to present the results of group discussion for other classmates need high-quality developed interaction support. However, once implemented, it surely decreases the disadvantage of one-way channel in traditional distance education. To communicate with a specific student, a teacher wishes to select most relevant partner among many distributed

attendants. *VIEW Classroom* helps the teacher to pick up candidates provided by student-history-database within the long term information such as test results, attendance, profile, and short period information of that day. Combination use of student symbolic representation and access to a representative student is effective for interactive communication and student's site analysis.

Question and answer facility

Most fundamental interaction between a teacher and a student is questions and answers. It's quite desirable and natural style that a student poses a question when she/he just has a doubt independent from teachers situation. On the other hand, a teacher should catch students' unsatisfactory responses quickly, and dissolve the problems as soon as possible. Although, in a distance education system with many attendants, there exist many issues with student questions, for example, excessive concentration of questions, duplication of contents, indistinctness of importance, vagueness of contents or expression, and others.

Answering those issues as to question and answer, *VIEW Classroom* proposes following three facilities:

(1) Question-submission support facility for a student: Student may specify a keyphrase and the location (figure and picture included) on teaching material, and question sentence as a target of question. Then a relevant question-menu is shown proposing to select a similar question if presented or to type in new question contents.

(2) Question-selection support facility for a teacher: Questions are classified with the similarity, and listed with the number of questioners. This function promotes teachers' easy selection and speedy answering. Moreover, if the teacher has set a weight on important key in teaching materials previously, the question related with the key word have a higher priority on question list. This suggests the strategic question selection is possible.

(3) Answering support facility for a teacher: If more detail about a question needed, a teacher may ask the questioner in class directly. Since all the process of answering is broadcasted to other attendants, the answers to similar questions shall be almost settled. And also the process are stored for attendants after class to hear the questions and answers. Commonly, a teacher is charged of a few classes in a session, therefor similar questions are likely to be asked repeatedly in every class. *VIEW Classroom* supports "Automatic Answering" using Question-Answer database. If the system recognizes that there exists similar question in the database, it quickly answers on the spot. This service offers vital teaching-learning environment where students may have courage of asking questions, and a teacher may grasp the students' interest and level of understanding in real time. Therefore the feedback to the lecture might be taken rapidly.

1.6 Outline of the Thesis

The remainder of this thesis is divided into 7 chapters. In Chapter 2, requirements for current advanced distance education systems which *VIEW Classroom* also should consider are addressed. In Chapter 3, several specific architectures which characterize this system are explained. Most of all synchronous and asynchronous interaction model plays central role in interactive communication in this system and also a leading part of this thesis.

Chapter 4, 5, 6 introduce the main facilities of VIEW *Classroom*. The author recommends to read these chapters in order. In Chapter 4, presentation and notation facilities are described. *VIEW Classroom* includes cooperative hypermedia system: *VIEW Media* which is one of the VIEW projects and has enhanced based on the requirements of *VIEW Classroom*. In this chapter, the related part is focused. In Chapter 5, facilities for symbolic representation for student's status and for synchronous interaction are explored. Since those facilities are essential for one-to-many interaction and related deeply, both facilities are introduced together. In Chapter 6, Question-Answer facilities is introduced as another application of synchronous and asynchronous model. In Chapter 7, following topics are discussed presenting remained issues and proposing future works.

(1) Enhancement of Synchronous and Asynchronous Model

(2) Question-Answer Facility in After Class

(3) Symbolic Representation for Mass Education

(4) Pedagogy for Higher Education

(5) Intellectual, Phycological, Cultural Distance

Lastly, Chapter 8 concludes this thesis, referring to technical bounds of computer assistance and educational bounds beyond the computer assistance.

Chapter 2

Requirements for Advanced Distance Education Systems

Distance education systems of today have been fairy diversified with target learners, educational objectivities, media, so on. Analyzing the common factors with distance education systems and teaching-learning process, essential and specific requirements for *VIEW Classroom* should be revealed.

2.1 Introduction

Different form traditional on-campus teaching, there are a lot of educational factors to identify current distance education system as listed in Table 2.1 where marked asterisk are *VIEW Classroom* adopted are marked asterisk. This table contains only a part of aspects of distance education systems, however, it suggests that there are many significant factors which must be examined and studied more to establish a system of this kind. In particular, "media" is prominent for the strong affection on teaching (or learning) material, distribution of material, teaching-learning style, communication tool, and so on. "Support organization" is also significant key of success, though, which is not main theme in this paper.

There are so many factors to discuss and extract requirements, however, we have limited to following five topics reasoning below.

(1) Teaching and learning style : as outlook of education

(2) Teaching material and notebook : as teacher's main resource and student's main acquisition

(3) Communication : as logical connection between a teacher and a student

(4) User interface : as physical connection between a teacher and a student

Table 2.1 Factors of Distance Education *: case of VIEW Classroom

Items	Choices
Education Frame	
Target Learner	School children / Undergraduate* / Postgraduate* / Professional* / Employee* / Adult / Woman / etc.
Education Objective	Compulsory education / Extracurricular lesson / Culture education / Study for degree* / Study for research* / etc.
Qualification Given	None / Bachelor / Master / Doctor / etc.
Education Content	Specific course or subject / Free*
Education Term	varied
Application Scope	Domestic / International*
Support Organization	Government / Academy / Industry / etc.
Current Number of Students	varied
Total Number of Students Finished	varied
Class Attributes	
Class Formulation	Tutorial (individual) / Group (class)*
Tutor in Charge	YES / NO
Assistance in Site	YES (attended) / NO (not attended)*
Learning Space	Classroom* / Home* / Office* / Public Space* / etc.
Study Time	On schedule* / Free*
One Session Time	varied
Teaching Method	Specific method / Free*
Media of Teaching Material	Print / Audio or video tape / Broadcasting (Radio or TV) / Telephone / FAX / Video-tex / Satellite / Computer digital text* / etc.
Distribution Means of Material	Post / FAX / Computer network* (E-mail, WWW) / etc.
Communication Tool	Postal mail / Telephone / FAX / E-mail / On-line network /Satellite / etc.
Language	English* / French / Germany / Japanese* / etc.
Interview Lesson	YES / NO
Report	YES / NO
Term-End Exam	YES / NO
After Care	YES / NO

2.2 Teaching and Learning Style

This section refers to class formation, learning space, teacher and students distribution, and teaching-learning activity and the process.

Class Formation and Space

Firstly, structure of class formation must be referred. There exist two basic types. One is tutorial type : a tutor (a computer) versus a student like CAI or WWW base, sometimes forming a class for the purpose of official matters. Another is group type : a teacher versus multiple distributed students who learn all together in a class. The former is superior in teaching based on personal ability and interest, however, the teaching method is too varied (human tutor) or standardized (computer tutor). Intelligent tutoring system may cover this field. While, in the latter it's not expected as close attention, care and speedy feedback as tutorial, however, mutual enlightenment through group activities is one of the essential advantages for higher education. Still more, from the viewpoint of educational and cost efficiency, group education is more effective and worthy of investment for computer support. Best solution, if possible, is dynamic and flexible class formation changing in a course or in a lecture.

Secondly, in case of group lesson, students' learning space is an essential factor to discuss, since in which support function differs. Typical and most convenient educational space is "classroom". The image of classroom is widely established, and also the rolls of teacher and student are commonly recognized. This common recognition of background is very important not only for system designers but also users to discuss and exchange requirements.

VIEW Classroom supposes group based and simultaneous teaching-learning environment using a virtual classroom where a teacher gives a lecture to distributed students at the same time. After the lecture, the students attended the lecture can review or continue self learning, and the students missed the lecture can replay it based on the lecture process recorded.

Teacher and Students Distribution

In distant education, basically a teacher and students are individually distributed. Practically, however, there are some types in the distribution form.

The first one is distributed classrooms: only one classroom is attended by a teacher doing a lecture facing with students, and the lecture is broadcasted to separated classrooms where other students watch TV monitor and communicate via microphone and camera. This form is often

found in multi-campus universities.

The second one is that a teacher gives a lecture independently in central site like a broadcasting studio. Students attend at an appointed place like a regional learning centers. If they have a receiver and monitor, it's possible to study at home or in office. Communication is served via leased line or public network like telephone. The University of the Air (limited to Kanto district) and private preparatory schools adopt this style in japan. Recently, satellite lecture services among colleges have started. Teachers' sites are changed in every subject, however this type falls in this category. Although communication means is different, On-Line University: an experimental project utilizing ATM (Asynchronous Transmission Mode) networks is also classified to the same category.

Third one is trendy computer network style: attending at schooling periodically, though, usually students study at home receiving learning material via network, returning assignments and accepting the assessment from tutor (or computer). On-line CAI (connected to host computer), E-mail-based or WWW-based distance education systems are included to this styles.

In the current systems in use, the second style is common, though, the disadvantage is that learners are forced to attend at a specified room where equipments furnished. This physical attendance is insufficient for a learning condition. Effective and successful distance education should be able to present an environment where a teacher and students can behave themselves in their own fields.

In *VIEW Classroom*, teachers and students are supposed to be distributed individually, communicating via computer network. This style includes groups distributed, and allows teacher and some students staying in the same room. Probably it's ideal circumstance for a teacher to give a lesson facing with some students directly since she/ he can recognize their responses. *VIEW Classroom*, also present the third style as self-learning environment after class. This system deals with both synchronous group activities in class and asynchronous self-learning activities after class, and regards those activities as a sequenced and connected activities, log of the learning history.

Teaching-Learning Activities

Following a subject from starting to ending, teaching-learning activities and the process are examined here so as to reveal requested functions.

Lecture planning

Subject matter is composed of some themes and topics. They are logically structured, sequenced and divided into physical lecture times. The structural relation is often changed and modified according to development of the domain, change of social requirements and so on. For example, the curriculum recommendation on computer science by ACM/IEEE* has been published new version in interval of 9 to 12 years since 1968, revising each subject every one or two years. Therefor, basic materials should be stored in database and restructured by flexible handling of the links. Far more important is in lecture planning is learning theory and strategy which are unlikely open, hereby difficult to reflect on system functions, though, system should be flexible to be modified by teachers' varying requirements.

Development of teaching material

After lecture planning, presentation documents, assignments, test, tools like simulation programs are prepared. Normally, the plan is fragmented and developed phase by phase, however, some teachers start the subject before completing the planning or the preparation. In higher education, the tendency will be stronger since the lecture is often modified depending on participants' interest, comprehension level or speed of understanding. Students still more give feedback information for teacher to evaluate her/his lecture and to reflect on materials for next class. Therefore, teaching material need to be flexible in structure and updating.

Figure 2.1 illustrates general teaching-learning activities and its flow. As for preparation, teacher confirms presentation materials and tools for the day, recognizing progress until last class. If the teacher of no or few experience, she/he may need "lecture simulation" checking facilities condition. While, some students also may request for review of last lecture. The preparation of these conditions should be considered also.

Instruction

Principle of teaching-learning process support : Instruction is not just telling process. There is principle of teaching-learning process to support. This is common recognition in educators, though, it is hard for computer designers to implement. In lecture, a teacher explain some themes presenting materials to students (stimulation). Student receives them in mind

*ACM : Association for Computing Mashinery
IEEE : The Institute of Electrical and Electronics Engineers

(acceptance) and reacts to the teacher by taking notes, asking questions (construction of idea). Recognizing students reactions (diagnosis), teacher also reacts by repeating, supplementing, stressing (evaluation). This cyclic and interaction process must be guaranteed or introduced to frame a system. To establish conscientious educational environment based on this instructional process principle is one of the subjects of education system support. *VIEW Classroom* tries to support the whole process above as interactive communication by synchronous and asynchronous model, yet, certainly it's hard way.

Awareness : Another important aspect in instruction is awareness. To make instruction effective, the consistence of attention at the same target material is essential. To put it concretely, the location that student is watching at is the same that teacher is pointing or underlining. The matter of course, students are free whatever they look, however, some means should be presented to know what students are referring as well as tools to lead students' attention to material.

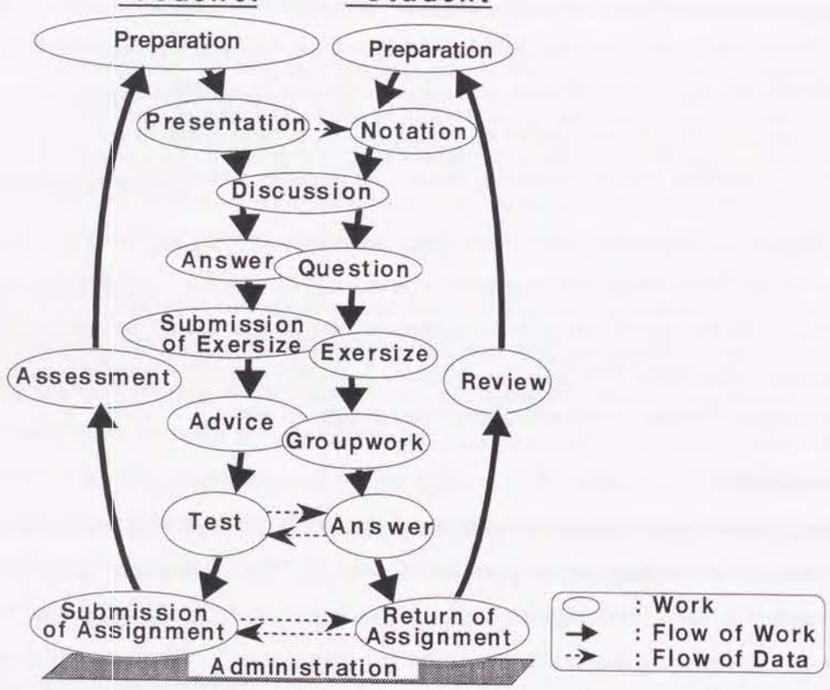

Figure 2.1 Flow of Teaching and Leaning

Control of data sharing : In multi-user environment, data sharing is essential issues to discuss. System must consider persons to present a material depending personal standpoint (e.g.. teacher, student, staff), personal belonging (e.g.. individual, group, class), and situation (e.g.. before instruction, in test, after class). System must controls the scope of distribution target according these attributes. Since user may have his own data secret, security control is also requested.

Control of student computer : There are many situation in which teacher controls student's (or all students') windows or operations for helping student's operation, emphasizing an ongoing topic, or hiding solutions during quiz, etc. This point is a specific feature of education support system different from other collaborative support systems.

Question and Answer

The most explicit representation of students' reactions is question. It is to be desirable that students actively and independently ask questions at any time since when in question is when to know best. However, an issue is emerged from such circumstance. That is, incompatible of teachers request that no question should interfere her/his lecturing and students' request that any question should submit any time and should be answered as soon as possible. Another issue is the coincidence of what students want to know best and what the teacher want to be asked (in other words teacher don't want to be worried with worthless questions).

What makes teacher worried in question is the vagueness in expressions and indistinct objective which suggest the support for converse question for more detail to the questioner. The conversation may be relayed to discussion mode.

Discussion

In higher education discussion is common and essential style. In current systems except telecommunication system, discussion by E-mail or other applications is possible, though, most of them are text-base in which troublesome typing is forced. After all, nothing is better than verbal discussion. However, in distributed environment, synchronous discussion with many participants is hardly controlled. Expected supports in discussion is selection and changing of speakers, presentation sharing with documents, question and answer, broadcast, and grouping in some cases.

To make discussion vital and effective, **recognition** support is also essential to know the

existence and responses of other distributed students. Different from discussion in physical classroom, virtual classroom has no audience actually, therefore, broadcast of live discussion can be connected to create audience by collecting and presenting audience's responses in symbolic manner.

Awareness and recognition are referred from the point of communication in following section again.

Exercise

For individual or group activity, many commercial applications like simulation tool and collaborative work software may seem to be supplied, however, in reality, those introduction to one system bring significant difficulties if the system adopted single platform. In addition, some applications may need multi-tasking operation. Those relates with the system structure (This problem is discussed in Chapter 7). If a system could offer such tools and synchronous control, automatic start and quit at some point or time, monitoring by teacher, logging the learning process, is desirable.

Test

Except exercises which answers are given in the lesson, there are tests or exams to evaluate the students at some periods. The issues of test in distributed environment is time difference. If same test must be used, all students must sit for the test at the same time. Even if it's possible, there is rather difficult to prove the examinee is the person herself/himself. Putting these issues aside, controlling of synchronous opening and closing test files are another burdensome request for computer support.

Assignment

Assignments are given to an individual or a group, as exercises in class or home work. Teacher's task after giving an assignment is monitoring, giving advise, assessment, returning the assessment to students, and managing the results. Different from test, the cycle is likely to be long, and since returning of results is not settled at the same time, the system should follow up and report the situation of the returning to teacher . In E-mail base education, they say that tutors are battling with a large number of returns, spending most of their time on the assessment. If assignments are digitalized and fixed in form, assessments can be helped by computer to a certain extent. Actually diagnosis and evaluation by computer program has been possible in

some systems.

As for a student, facilities for making reports or doing some achievement are needed to be prepared. To do that, not only classroom but also academic facility environment like laboratory (simulation room), virtual library, study-counseling room may be necessary.

After-class activities

Figure 2.2 shows educational activities supposed in *View Classroom* in which some activities are continued or connected to activities after class. We address the time zone of teacher attended for a lecture "in-class", and the zone of self-learning after the lecture "after-class". The reason why activities in lecture are relayed to after-class is that there are review by attended students or lecture-replay by the nonattendance. With related with student presentation in Figure 2.2, there is various styles like presentation video tape is sent or present by post or on network later.

The figure also suggests that the after-class support is very important in distance education since due to the characteristic nature of time distribution, most of students who registered

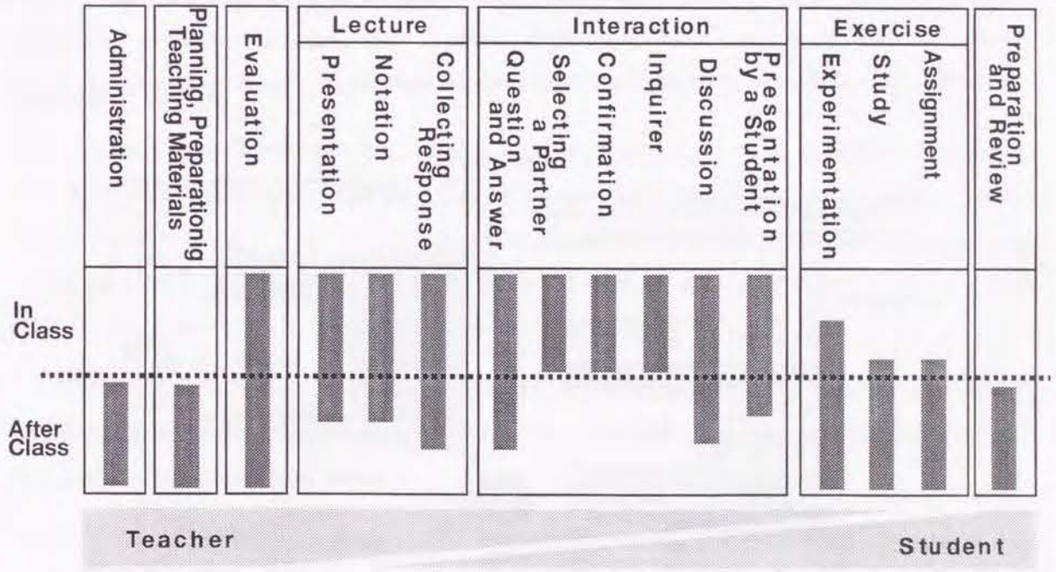

Figure 2.2 Teaching and Learning style

actually unable to attend the class on schedule. To guarantee the equal quality of education to the nonattendance, lecture live record should be available at least. Furthermore, the record should be applied to enable them to take participate in, for example posing questions or sending messages during replaying the lecture. It also holds true here that the academic facility environment is important for after-class activities.

2.3 Teaching Materials and Notes

In any subjects, even if exercises and discussions are centralized, teaching material play important roll to make students understand. In this section we discuss the issues and requirements on teaching material and student notebook which are important educational resources.

Hypermedia

Today, media for teaching material is too diversified to select. In such circumstances, WWW brings some capabilities for teachers to make attractive multimedia materials. Although, it is not enough for students at present since WWW client has a little ability of replying without developing application. On the other hand, challenging of digitalizing all materials including audio, video and picture on ATM networks is proceeding [AGZ96], however, it doesn't seem to be so successful up to now (handling of digital video is hard task). Nevertheless, multimedia, networks, and database is never neglected in advanced distance education system today, and the

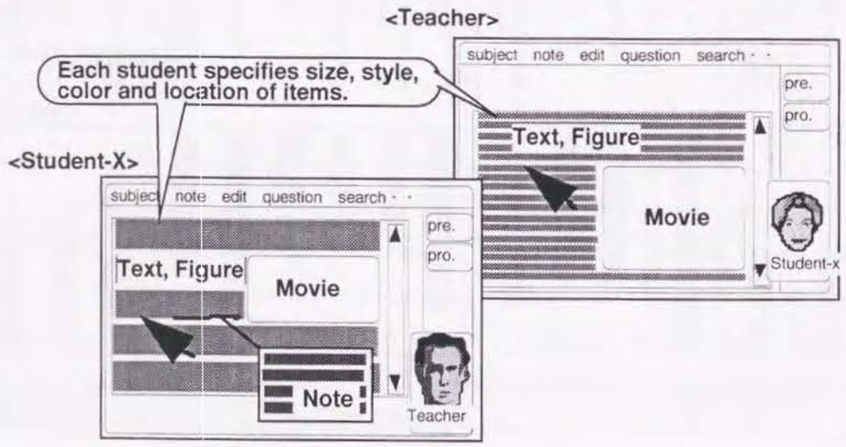

Figure 2.3 Customized Students Window

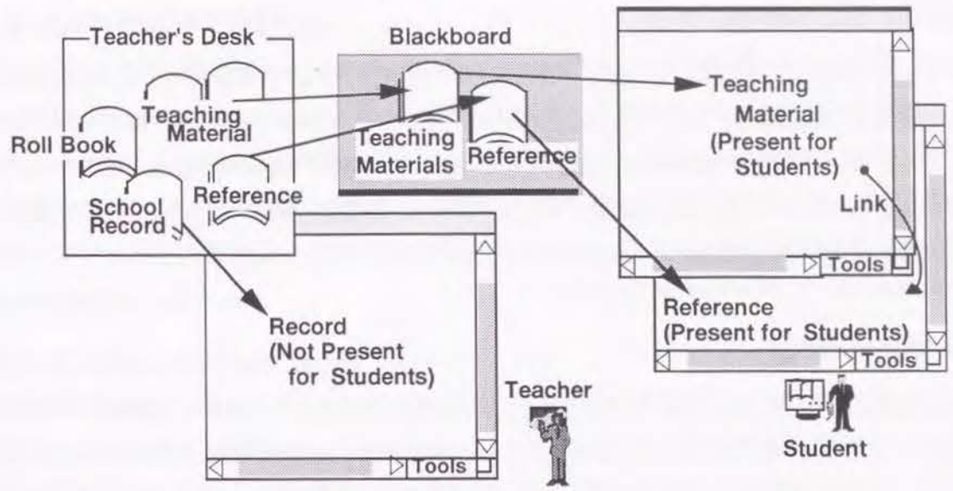

Figure 2.4 Presentation of Teaching Materials

way to integration of media will be made progress far more. Recently hypermedia is payed much attention as means of realizing interactive lecture using multimedia documents. In *VIEW Classroom*, *VIEW Media* : cooperative hypermedia system is offered as presentation tool in lecture.

Update in lecture

Until recently many commercial authoring tools or system have been appeared. The author have used a tool of this sort for many years as it excelled in visually appearing, though, it was too time-consuming job and found the most disadvantage is inflexibilities in update or reconstruction of materials promptly in lecture. To update or modify material on the spot is quite essential requirement for higher education in speedy age.

WWW excels in linking materials, though, it still insufficient for cooperative work, since it's originally developed for single user. It is expected that functional extension to enable users to take participate in more and more.

Hypermedia has brought much possibilities of performing dynamic teaching and learning. Multi-users and multi-links are powerful for sharing material, flexible use and update .

Long life material

Content of educational material including tools like simulation is naturally getting old so soon that some numerical values should be updated, and new concepts or terms should be added or deleted. Once a material has been delivered, it's generally destined to be abolished after a while even if much cost and time was payed. There could be long life material which are renewed and developed frequently not only by authors but also students requests and updated one (or transaction) should be available on network.

Effective notation

Traditional teaching material presented by teacher is generally made independently from student notebook, forcing students to copy the contents on notebook (by hand at worst). This work hinders students from concentration on understanding subjects. Digital text contributes to the reduction of students' notation for easy copying (another issue with copyright is emerged, however). Hypertext and hypermedia have also contributed students' effective notation allowing adding personal comments, linking with related materials on personalized screen.

Consistency of materials

Separation of presentation material and student notebook cause problem of inconsistency. Once material has been delivered to students, teacher's update doesn't reflect without notifying the change. The necessary is the mechanism that enable notebook to be modified by student and also allow teacher to update.

Personalization

In days of OHP (Over Head Projector), we were suffered with the small letters on the sheets. On computer screen, the same kind problems are remained. It's reasonable for students to request that the character size, window size, color, etc. should be under control. Further more, students learning environment should be personalized overall. Examples include that navigation in presentation materials independently, notation in personal area, communication with other classmates, etc.

2.4 Communication

Communication in educational domain is still central subject in our age with highly developed communication facilities. In this section, communication issues in distance education are discussed including students' responses and the dealing. In physical classroom, teacher can communicate through voice, writing or drawing on blackboard, face expression and body action. The means are quite limited in distance education environment, though, system is still more requested as follows.

Synchronous communication

Table 2.2 shows the classification of communication functions by teacher. Advanced CAI systems have assisted these presentation, response control, evaluation, and KR (Knowledge of Results), and are shifting to knowledge-based tutoring system [Mur96] or intelligent tutoring system (ITS). However, CAI system is basically a substitute for teacher(s) and regulation by tutor (system) is too strong. Accordingly, interactive communication with human tutor for consultation or else is still requested.

Recently not only E-mail or WWW based communication systems [Gil96] but also integrated E-mail and WWW based systems [AC96] have commonly reported. These are not synchronous, however, educators are facing with the problems of time delay between ongoing

Table 2.2 Teacher Communication Function

Class	Function	Contents
Presentation	Presentation of Information	Goal, Presentation of material, Explanation, Notice
Control	Arousing	Request, Question, Naming
	Instruction, Caution, Leading	Instruction, Causion, Leading
Evaluation	Diagnosis & Evaluation	Monitoring, Observation, Diagnosis
Knowledge of Results (KR)	Intellectual KR	Affirmation, Negation, Correction
	Emotional KR	Encouraging, Admiration, Scolding

lecture topics and replays to old questions, few participants on Web page as communication board (most subjects were settled more quickly by other media), valueless conversations as uncontrolled results, etc.

Contrivance for interactive communication

One-way nature of media in many distance education systems of the second generation results in little communication from students to teacher. Given high-quality network facilities, interactive communication have made drastic increase, however, active function support for student to pose some responses in lecture have not found. One of the reason is the inheritance of educational regulation in traditional classroom where students should be under the control of teacher. To activate distance students, system should offer the means to make teacher known their emotional responses. That is, not after but just in the lecture, responses like impression about the lecture should be sent to the lecturer on-line for example using response button which say " hardly understand", " too fast to follow", "more in detail", etc.

Non-video-based tools

If a class is comprised of a large number of attendants, it becomes impossible to present all students images on teacher's screen at the same time. Thus some non-video-based tools must be provided for pointing a student as a conversation partner, collecting and presenting their responses in real time.

Previous measures for effective communication

In limited lecture time, if teacher hopes enrich communication, to select a relevant partner under specific conditions and to get informations about the student in advance is quite significant. Such prior countermeasures for smooth communication should be assisted in advanced system.

Collection of voiceless responses

Communication is not always exchanged by active means of voice or message texts. Also, demonstrated messages does not always present internal reflection. Students also express their messages by behavior of mouse operation. For example, the lecture is too monotonous or worthless to listen, they may try to open following pages or start navigation among unrelated documents if allowed to refer. These objective data are valuable and interesting for analyzing for interrelations with other learning achievements and results.

Supply of communication chances

Communication is commonly started after seizing some opportunity or motivation caused other students or teacher. Therefore, system should present the chances and contents for active communication concerns the lecture or students' situation.

Representation of responses and recognition

In large class, situation of each student and whole class is difficult to represent on a small screen at the same time. So, making use of advantage of computer, the computing processing technique should be utilized for representation of responses through summarization, abstraction, symbolization and visualization, etc. Then, the representation should be shown to all the attendants in the classroom to let them know what are other students like now. This contribute the recognition of other students in deferent locations.

Communication among students in lecture

While lecturing, system should allow students to communicate with other classmates. In physical classroom it may be prohibited because chattering interferes the teachers' instruction, though, in virtual classroom it is not problem as long as it ends in short (warning needed if it's too long) and not interfere the partner (calling permission necessary). The reason is that as known through our experience in student days, the best and quickest answerer was the classmate of next seat.

Recognition in one-to-many formation

In distributed environment, recognition of students is essential as communication foundation. For a teacher in one-to-many class formation, communication is performed basically one-to-

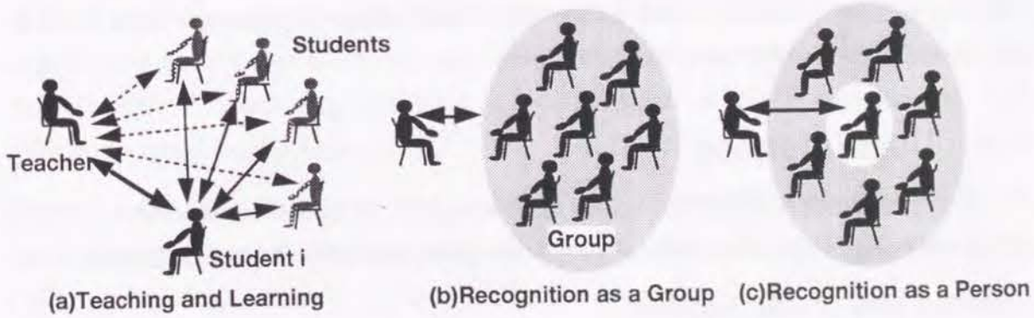

Figure 2.5 Recognition Image of One-to-Many Interaction

one, however, from the stand point of educational efficiency the communication should be shared with other attendants. Broadcast is effective means.

At discussion or other cooperative work, students may be grouped with some categories like progress, skill, research domain, age, etc. Accordingly, communication scope is switched to a group or a person in a group as shown Figure 2.5. Thus, class formation or group formation affects the recognition and access scope. From the stand point of a student, her/his communication in lecture also should be one-to-many (Figure 2.5 (a)) as discussed previous paragraph.

Access limitation

In the same classroom, attendants may communicate each other. However, there should be limitation in some cases. For example, if teacher forms groups for discussion, supplying meeting table or rooms, a group can compose a communication unit. That is, a member cannot participate in the communication at other meeting tables even in the same classroom without permission. Naturally, classroom is different, students are impossible to access each other, though, mutual exchange of temporal students (as auditors) to attend at related subjects may be interesting trial.

After class communication

Matter of course there are many media for getting contact with other students after class, though, communication using teaching materials in same learning environment should be supplied to student. Especially when a lecture has just finished , the needs must be highest. The classroom should not be closed for a while for after-class dialogues.

Bulletin board in classroom also should be used actively not only for notice but also for students questions which are open for answering from students (partly because some questions are surely remained unanswered at teacher side).

2.5 User Interface

As *VIEW Classroom* is framework system at present, detail user interface on screen or window design, have not discussed enough. In this section, therefore, some concepts are stated.

Different view of user interface

Education system have generally two kind of major users. One is students who's user interface

should not request long lessons and should be able to be learned by analogy of common knowledge since they are short resident and may be finished in almost beginner level in the system environment. On the other hand, as to teachers who are relatively long inhabitant, their user interface should base on knowledge accumulation through experiences of repeated lectures. Thus, character and quality of user interface support different on the stand point of learner and educator.

Representation by metaphor

To make interface understandable, the representation of classroom environment on screen should be used like metaphor with which associate a physical classroom. Accordingly, objects related space are presented like classroom, laboratory and meeting room. Also, as objects of tool, blackboard, platform, teaching materials and as objects of person are as teacher, student, staff are necessary.

Intuitive interface

Essential request for user interface through lecture is representation which brings intuitive comprehension of situation. Within a limited time, attendants are busy in taking notes and following instructions. Command line or guidance with long messages which occupies screen is nothing more than obstructive. Therefore, functions necessary should be iconfied and presented automatically at relevant situation. Color, blinking, small moving animation are good tools to catch eyes.

2.6 Summary

In this chapter, requirements for advanced distance education systems are classified. There are so many aspects to consider in distributed environment. However, as we have seen, most of requirements don't always tell the specific features of geographic and time distribution. Not only educational system of general purpose but also E-mail or WWW-based system could introduce some of them in any way.

As a matter of course, every educational scene is never ended independently, it's followed by another scene relaying the previous results. Therefore, system must support a teacher to plan,

do, see with continuously connected facilities. Details of support facilities in *VIEW Classroom* are explained according to the instructional process or sequence of necessaries in following chapter 4,5,6.

Chapter 3

Architectures of *VIEW Classroom*

To meet the requirements described in previous chapter, *VIEW Classroom*: proposes some architectures which bring specific features of this system. The major concerns are related with study material, communication, and practical system structure.

3.1 Introduction

There are five specific features on designing the architectures of *VIEW Classroom* , those are (1) educational document structure based on cooperative hypermedia, (2) applying advanced database function (3) synchronous and asynchronous interaction model, (4) transaction filtering and abstraction, (5) distributed system structure.

These are all based on technological basic foundations below:

- One-to-many class formation attended by distance students
- Live lecture together with distance students on network
- Replayed lecture by after-class attendants based on teaching process record
- A server and distributed database

The following guides the basic concepts on each features.

Educational document structure based on cooperative hypermedia

In *VIEW Classroom*:, teaching materials are mainly offered as hypermedia documents by *VIEW Media* which extended the design for distance education. The document is shared with multi-users and have multi-links which enable the same documents to use in different purposes and relations. Moreover *VIEW Media* provides for student (1) customization of hypermedia, (2)

customization of view, and (3) customization of navigation. These feature propose flexible learning environment.

Applying advanced database function

VIEW Classroom is client-server system. Data are distributed to a server's or users' object-oriented database according to the applications' objectives. In this database system view concept is introduced to define screen view which present multimedia documentations. With view definition, adjusting of window size or overlay becomes possible. Also, sharing data are defined including view definitions.

Synchronous and asynchronous interaction model

VIEW Classroom regards teaching-learning process as synchronous and asynchronous interaction. Most typical synchronous situation in lecture is interaction sharing with teaching material on each screen. Student independent actions like selecting a question from menu or referring other pages are supposed asynchronous. Student transition between synchronous and asynchronous situation is repeated through lecture creating response transactions. In this approach, transition can be followed by other synchronous (or a synchronous) situations changing the instructional styles. Note that a human being can recognize both asynchronous and asynchronous situations. That is to say, while a student is in asynchronous situation, she/he can roughly perceive the another situation and if necessary, transition can be done immediately.

This transition model of going and back between synchronous and asynchronous situation is found in any cooperative works. This model reveals what a system should serve for a user while in one situation and also when turns back to another situation.

Transaction abstraction and filtering

In one-to-many formation, from "one" to "many" communication is easily implemented using broadcast. However, from opposite direction "many" to "one" causes many technical and practical difficulties. *VIEW Classroom*: proposes
This approach is applied to visual symbolic representation to recognize students status (see Chapter 5) and also to extracting essential questions (see Chapter 6).

Distributed system structure

From the nature of one-to-many formation support, system is forced to have heavy traffic concentrations on a server and specific database in many situations such as dozens of questions

at certain document, simultaneous replies according to teacher's instruction, etc. To avoid this sort of concentration, this system adopts distributed structure which is tunable according to increase of attendants.

3.2 Educational Document Structure Based on Cooperative Hypermedia

Hypermedia

Hypermedia is an extension of hypertext and its original idea of Dexter-model is introduced in [GT94] . Recently the model has been widely extended including variety of concepts like n-ary links, time, context, hierarchical structure, and so on. Hardman, Bulterman and Rossum propose extentions to the Dexter-model to handle dynamic media [HBR94]. Multimedia documents consist of components of static media (text, figure and picture) and of dynamic media (audio and video). Components of dynamic media are changed according to time or lecture style. If multimedia documents contain more than one media component of dynamic media, issues of synchronization among these components becomes important. Figure 3.1 (a) shows a multimedia document presentation with multiple dynamic media components. As media components can include time-based media, links can be used to retrieve relevant media components or navigate to time point. Hypermedia consists of multimedia documents and links which represent relationships among multimedia documents. A part of multimedia documents can be defined as an anchor. Relationships among multimedia documents are represented by links among anchors as shown in Figure 3.1 (b).

Grønbæk, Hem, Madsen, and Sloth present cooperative hypermedia systems [GHMS94] intending large-scale sharing of hypermedia structure by all applications in a wide-area computing environment.

As we have seen above, hypermedia is highly expected as most relevant and powerful teaching-learning environment for world wide distance education.

VIEW Media

VIEW Media [Kon95] is collaborative presentation system designed as a distributed version of hypermedia based on Dexter-model. Utilizing object-oriented database, presentation materials are stored in hypermedia database as media objects. The documentations are shared with

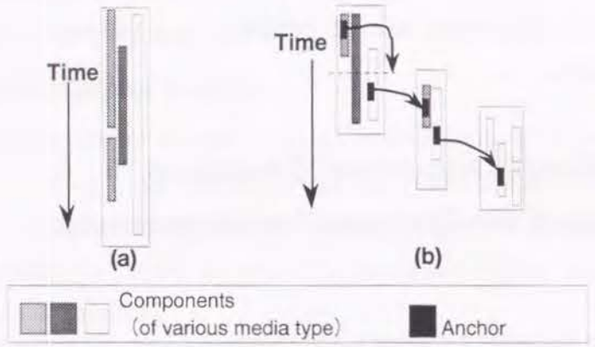

Figure 3.1 Multimedia and Hypermedia

multiple distributed users in cooperative environment. Since conventional hypermedia is designed for single user environment, *VIEW Media* has been requested to extend the design for on-to-many type distance education.

In this section, only the design related with *VIEW Classroom* are described.

Customization mechanisms

VIEW Media attempts to provide flexible user environment featuring by following customization mechanisms in interactive presentation.

(1) **Customization of hypermedia components** : User can modify hypermedia components. For example student can write comments on the presented text using conceptual transparent sheet on it, or adding links with other components. This mechanism allows students generate their own notebook (note database). To preserve the original components (teaching materials), "virtual update" is provided.

(2) **Customization of view**: User can change materials on screen as to the window size, character size, color, and so forth. Hereby, teacher and student can make her/his own view adjusting to mechanical or physical conditions.

(3) **Customization of navigation**: User can navigate in hypermedia documents. This enables students to retrieve informations presented before in class and to review the lecture after class.

On-line update

During lecture, teacher can change the sequence of presentation or add new materials. This modification is possible to reflect on the teaching materials which had been distributed to attendants.

Representation as Metaphor

In order to apply to various systems, VIEW *Media* use metaphor as representation means of independent generic information. Metaphor dependent information such as the structure, shape, and color are stored separately. Thus, attributes of blackboards, books, notebooks and other special equipments are defined flexibly and easily.

Organization of teaching materials

Figure 3.2 shows an organization of teaching materials using *VIEW Media*. Each hypermedia document is divided into pages. One page is the unit of display, although a teacher can show only a part of a page. There are several kinds of anchors, like anchors to teaching materials, those to references, and those to related questions-answers.

Display of more than one document is possible. It is omitted here since it is similar to the definition of multimedia documents. If teacher do not want to break a lecture for questions he can define break points to process accumulated questions.

Hypermedia database

Hypermedia database (hyperbase) [Kon95] is active object-oriented database (OODB) system with node and link service mechanism. Media objects in the hyperbase are selected and combined in the external schema and presented on a screen. On-line update on the hyperbase is performed like that the update transactions are stored as presentation specification and broadcasted to students before reflecting them in the hyperbase. Then after student asking the permission they are integrated (when permitted) or stored separately (when refused).

Data allocation

Hyperbase view definition and presentation specifications are stored in local databases in client-server environment. Teaching materials shared with students and meta-information for data sharing are stored in common database at server. The facilities for customization are allocated in local and common database both. Group sharing data is replicated at members local database. Thus, data allocation depends on the objectives of application.

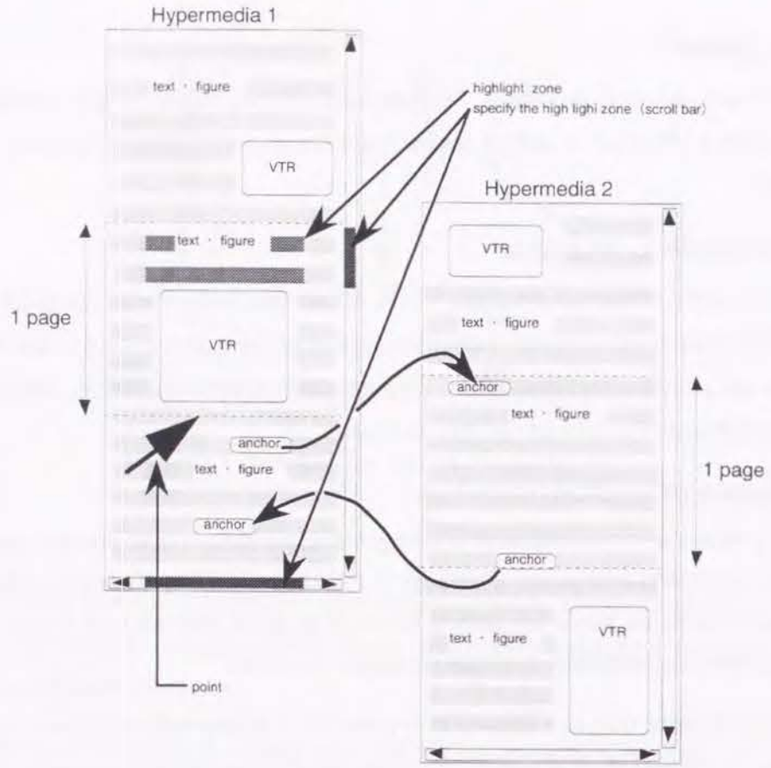

Figure 3.2 Organization of Hypermedia

3.3 Applying Advanced Database Functions

In this section we discuss database functions for *VIEW Classroom*. In this system, the data are stored using class hierarchy of object-oriented database. When the databases for *VIEW Classroom* are designed, the three elements as well as schema designs of the databases have been considered. Those are (1) selection of data to store, (2) definition on data presentation, (3) definition on data sharing.

Selection of data to store

There are a lot of data generated in traditional classroom. In our distance education system, data to store will exceed in quantity, since there are various transaction data created with students' actions in class. The data to be stored in our system can be classified as follows:

- Data reused in lectures : Data for teaching materials and reference documents are often recreated and combined in preparing lectures. Those hypermedia documents are stored in hypermedia database as media objects. Also class administration data (and school administration data) may be referred for student selection, however, those are separately managed in persistent database.
- Data generated in lecture : Through lecture, teacher and students dynamically produce new data such as questions, answers, speeches in discussion, replies to teachers instruction, comments, underlines, and others. These kinds of data are usually additional to the data prepared for lectures or notebook. As to update transaction related with teaching materials, these are stored separately to support virtual update. Data which represent students' status and data represent students' actions are also generated during lecture, though these are treated in temporal database.
- Relations among data : The relations among data are also regarded as data. For example, teaching materials, reference documents, and students' notebooks are related in notation. Also, questions and answers must be corresponded each other. These relations are represented by links. There are two types of links: predetermined in preparation and generated during lecture.
- View definition : View definition data is also included in databases for *VIEW Classroom*. Using views, some part of data can be hidden, some can be shown as combination of data, or as summarized data, etc., without affecting other data. Combinations of data can be just a nameless set of data, however, if the data has some semantics by itself, the data can be synthesized under the semantics.

Definition on data presentation

Unlike physical classroom, teacher and students are in use of computer through a lecture, the design of user interface of the databases should be flexible. Specification of data presentation is as important as designs of database schemata. In data presentation view object is utilized. That is, data are presented in different visual forms when combined with different view objects. When a screen has several presentations of data items and the screen size is not wide enough to display all the items, windows of a set of data items can be managed. The view object for a set of data items presented on a screen can be defined to manage the presentation by, for example, adjusting the size of windows or overlaying windows.

Definition on data sharing

In CSCW systems like *VIEW Classroom*, design of data sharing schema is also significant.

Data stored in *VIEW Classroom*, namely, data prepared for lectures, data generated during lectures, relationships among data, and view definitions could be shared. Sharing objects can be utilized for definition of data sharing. To share a material teacher could present it at the top layer of student screen. Various levels of data sharing can be supported utilizing sharing objects.

Class hierarchy in VIEW Classroom

Figure 3.3 shows a class hierarchy of data used in *VIEW Classroom* . All the nodes are classes in object-oriented databases. There are three kinds of links: generalization link, reference link and set reference link. Data are classified into management data, data given by students, and data given by teacher. Data given by students and teacher are clearly distinguished since the flow of information is different with the sender.

There are documents related closely; teaching materials, notebooks and bibliographic documents. Notes may refer teaching materials and document explanation may overlaid on another document. Tests or exercises require interaction among a teacher and students. If a request or question is issued, a object in response or answer is created and the objects in each class refer each other.

3.4 Synchronous and Asynchronous Interaction Model

Synchronous situation for example is that teacher is giving a lecture pointing sentences or pictures, while student is listening and following the instruction. At one moment a student may perform independently, typing a message for submitting a question or referring other pages, etc. which are asynchronous situation. After a while, the student may be back to instruction, a synchronous situation.

Figure 3.4 presents the synchronous and asynchronous interaction model in cooperative work like question-answer and discussion. This model is applied not only in-class but also after-class. In lecture, a class is held based on synchronous actions between teacher and students, and student's independent actions are supposed asynchronous.

On the other hand, in after-class, student communicate with teacher or other students using E-mail which is asynchronous communication tool. Even in basically asynchronous circumstance, synchronous situation could be generated. For example, a teacher may call a

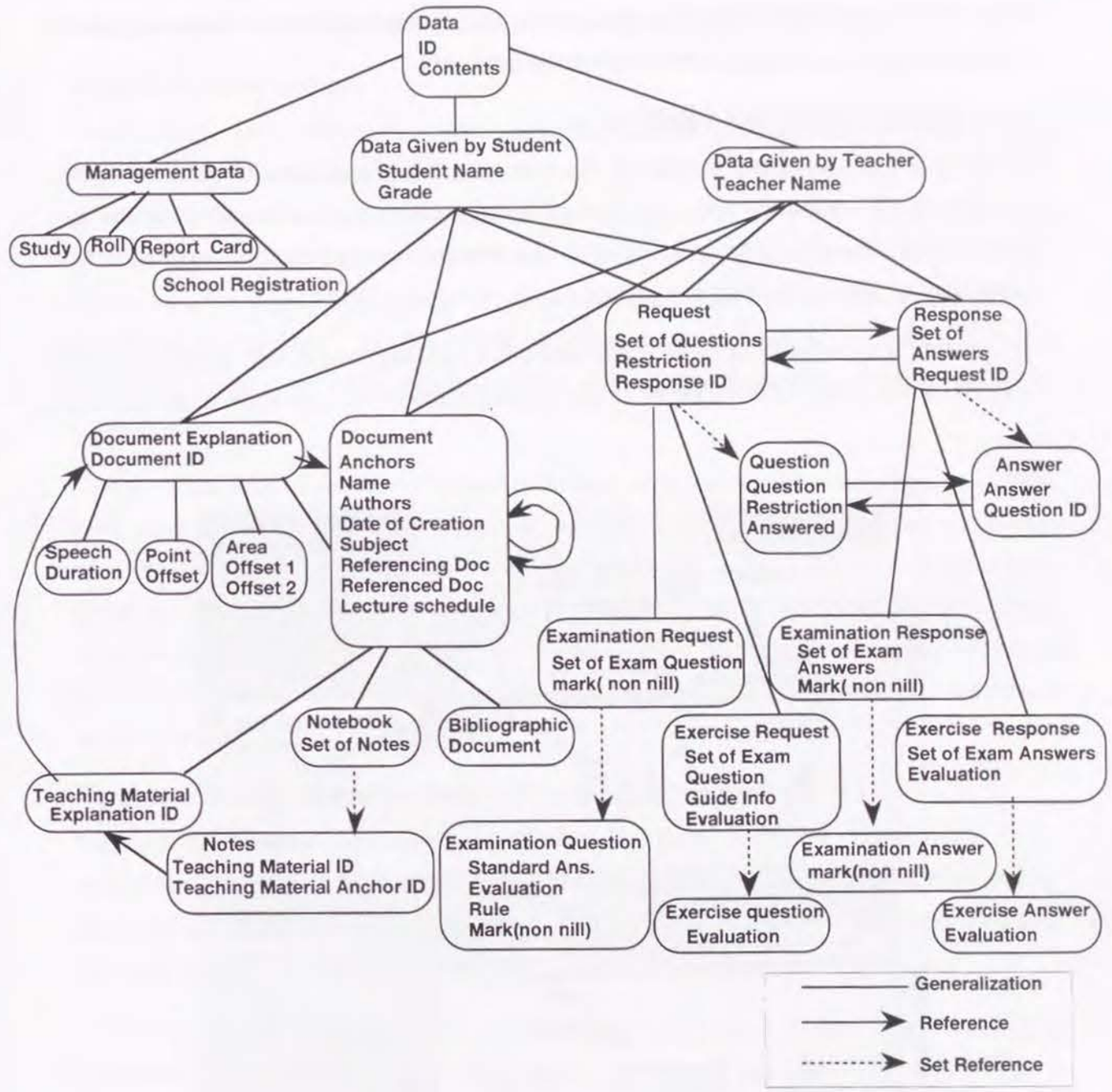

Figure 3.3 Class Hierarchy of VIEW Classroom

student who submitted an uncertain question in intention or expression, and if necessary direct communication can be started including the attendants at the moment. Cooperative work with other group members also could be synchronous calling the members via electronic bulletin board and opening a meeting room or classroom temporary.

Temporal and persistent database

In Figure 3.4 two databases are shown. They are distributed databases. One is a temporal database stores temporal transaction data such as questions and replies which is changed moment by moment. The transaction is the results emerged from synchronous and asynchronous learning process of each student.

Another is a persistent database stores data which last long such as test results, attendance records, and profiles. These distributed database transactions are summarized and translated

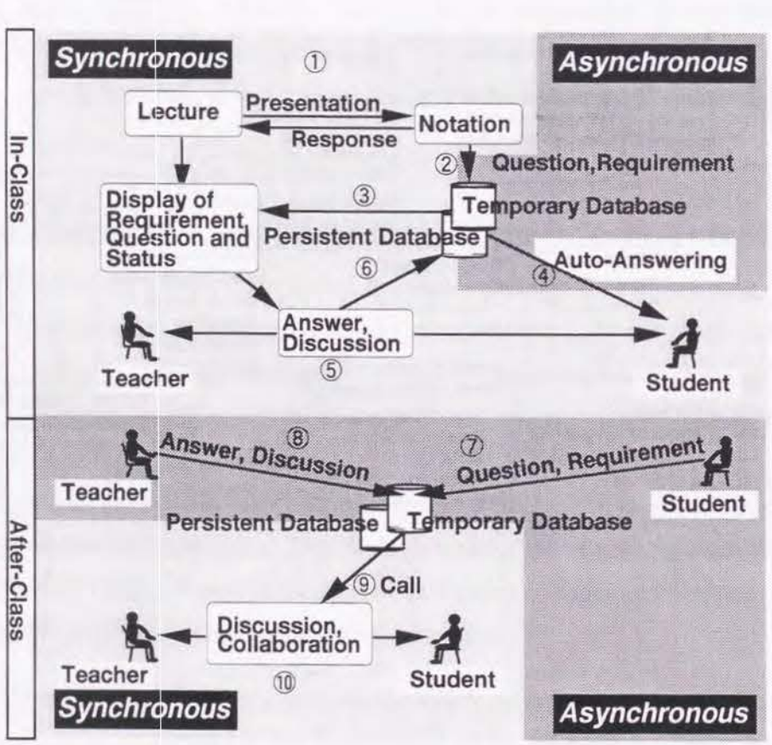

Figure 3.4 Synchronous and Asynchronous Interaction Model

into renewed ones which play roll of trigger to following transitions of students and teacher. Also they provide informations about temporal features of each student which are used for example, to select a specific student under some conditions specified by teacher.

Parallel multiple actions

Human being is gifted with doing multiple actions in parallel. We often read a newspaper along with watching TV, chattering with family. For network users it is quite common to access to E-mail while having other application programs run at background. This holds true in educational circumstances, busy learners are never satisfied with occupation of computer by single purpose. Hence, a system should support parallel multiple actions, namely for system concurrent multi processing is requested . In educational situation, main performance is matter of course synchronous action with teacher's instruction, and other independent actions are possibly asynchronous.

The author thinks that there is no need to define synchronous and asynchronous so strictly, since most actions are more or less involved another situations each other. However, system must get some clear switching chances. In this system for example allows student to pose questions. Firstly anchor is set by selecting a key phrase in a teaching material and then related question menu is displayed proposing to select one from question list if any, or to type in question content. In this sequence, when an active menu of teaching material has turned inactive could be supposed the timing.

Presentation and preservation of synchronous process

Adding to the flexible environment which allow asynchronous actions in parallel, one merit for users derived from this model is the service for presentation of synchronous teaching process while user is engaged in asynchronous action. Therefore, student can be in asynchronous at ease watching roughly with a side glance to catch her/his specified key word is appearing.

Another is preservation of synchronous teaching process the user has lost while in asynchronous situation. When a user has returned synchronous situation, she/he may be helped if system shows the point to go back. If the point is far away from present point, the user can replay after class based on the information.

Application

This synchronous and asynchronous model is applied in this system to question-answer (see

section 6.2) and discussion facilities (see section 5.3), and shall be adopted to other groupworks in future. As there are many interactive situations in cooperative systems such as conference system, virtual office system, computer-supported meeting system, this approach shall be useful.

3.5 Transaction Filtering

Synchronous interaction in on-to-many formation, many (students) to one (teacher/student) communication is certainly expected to cause heavy traffic concentration to a server. This major solution is to decrease large quantity data transmissions as possible at each site of student, server, and teacher. Moreover, the concentration involves a teacher in a flood of informations and disturb her/his concentration on instruction itself. Teacher only need requested informations. To answer these requirements, three transaction filtering approaches are proposed. Those are (1) classification, (2) modeling, and (3) abstraction approach. Each feature is as follows.

- Classification approach attempts to retrieve essential information by classification.
- Modeling approach is based on selection of students similar to specified model. Sample students only become targets for collecting transaction. This approach in other words tries to abandon unnecessary transactions.
- Abstraction approach helps transaction reduction through abstraction processing. This approach also contributes for visual recognition since using symbols and colors.

Classification approach

This approach is found as classification of questions in Chapter 6. The specific character like question transaction is the similarity of contents, especially most of question depend on teaching materials. This kind of transaction could be classified and presented the representative ones. Problem is the techniques of classification and it differs in transaction features. Since questions in *View Classroom* are allowed to type question text in natural language (Japanese) as well as select one from menu, linguistic analysis is requested to classify into semantically equivalent questions [WKK96a] [WKK96b] [WKK97]. At last phase, representative questions with the frequency of the questions so as to get only essential questions easily. The detailed solution is described in section 6.3.

Modeling approach

decrease transaction using empirical knowledge. This approach is effective for repeated and large class. At the first step, it starts with collecting all students' response transactions and then summarize and extract "model student(s)" (top, average, bottom student could be) studying relations between student's attributes (skill, test results if finished, age, etc.) and responses like mouse operation, question frequency or others. The number and criterion of model selection depend on teacher's strategy. At the second step, actual students who's actions are similar to model student's behavior are selected. Student selection facilities are provided. At next class, only the specified students' responses are collected. Teacher can presume whole class tendency through these sample students' behavior. This may need repeated trials reason for empirical approach, however, this may result that load to system is minimized and effect for teacher may not so much different with the tendency of all students behavior in the class. Most important is however, system allows each teacher to select only interesting information. However useful the information is, if the teacher is not interested, it's just redundant nor interruption for lecture. This suggests system to provide personal operation environment for each teacher.

Abstraction approach

The third solution is abstraction of transaction data from students. In *VIEW Classroom*, this approach is applied in symbolic representation for students status (see Chapter 5). Using symbols and colors , individual and whole class situation is represented on visual student-seat-map (virtual classroom) which also helps easy selection of communication partner under certain conditions. The map is broadcasted not only for teacher but also students (if necessary) to recognize the other users responses. This abstraction approach decreases data transmission from server to teacher or student. And more, the combination of filtering and abstraction approaches will be more effective for reduction of transaction.

3.6 Distributed System Structure

One of the most important issues in communication is responsibilities. In synchronous communication especially, heavy concentration by students to a teacher or specific server is expected. This leads to break up communication at worst. Therefore, to avoid over concentration or distribute them is subjects of this kind of system. By replacing video by symbolic representation, a large amount of data transmission will be reduced. And some transaction reduction approaches as mentioned before could contribute to some extent.

Kernel object and function object

Furthermore, *VIEW Classroom* have distributed system structure which makes it possible to realize an interactive lecture with a large number of students. Figure 3.5 shows that VIEW *Classroom* interaction structure is composed of two types of object : "Function Objects" and "Kernel Objects". The Function Objects to present windows and correspond for the replies are synchronized each other via Kernel Objects. Function Objects send messages using logical destination name and data name. While Kernel Object analyses request logical messages using database and sent messages to destination object by communication facilities. This Kernel Object contribute to establish the distributed structure playing the roll of offering logical transmission channels and keeping modularity of Function Objects. Note that the messages between a teacher and students should not always access a server. They can communicate directly to avoid traffic concentrations.

Figure 3.6 illustrates the relation between Function Objects and Massage Manager. In *VIEW Classroom*, each window has Function Objects. Function Objects send logical request messages to Massage Manager. Based on organization table on which destinations are listed, Massage Manager replaces logical request messages to physical ones, and send to database or destinations requested. Function Objects, therefore, can synchronize each other through Massage Manager.

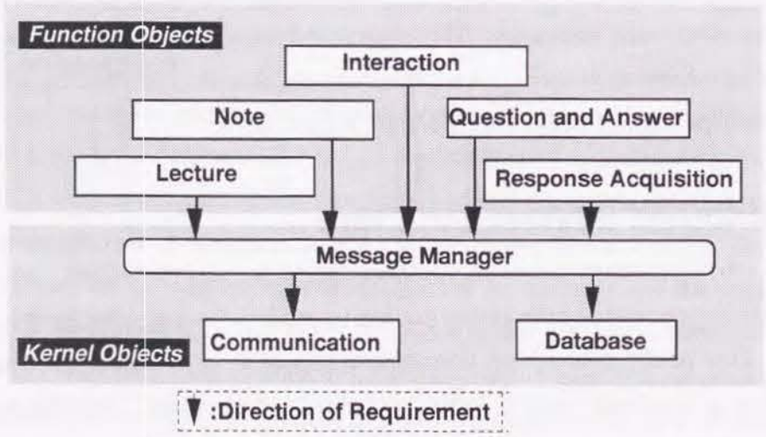

Figure 3.5 Function Objects and Kernel Objects

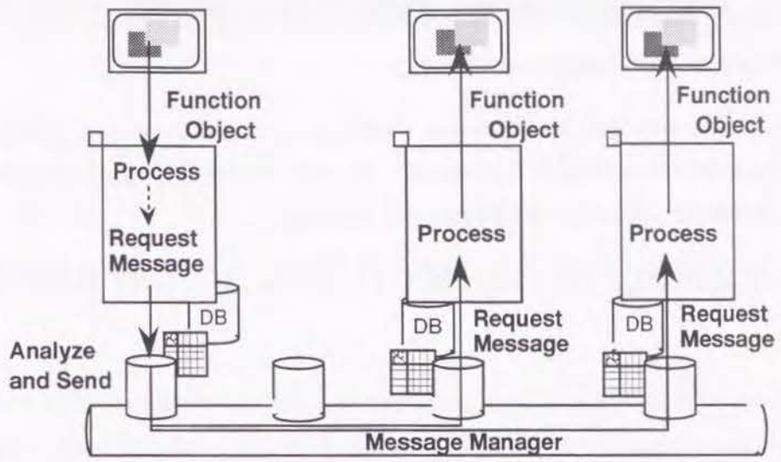

Figure 3.6 Function Objects and Message Manager

Empirical control

The traffic concentration level of communication is evaluated and controlled by database architecture and Kernel Object via network to some content. Still more, the master in education system is a teacher. She/He can lead or control students to do or not to do certain actions which is estimated over concentrations. This is specific feature of computerised education system like *VIEW Classroom.*

3.7 Summary

Virtual classroom in *VIEW Classroom* is a specific time and place dependent environment where synchronous and asynchronous communication is mixed in class and after class. The communication is formed one-to-many relation not only from the standpoint of a teacher but also a student. In this relationship, essential points to support are "sharing of environment" and "the recognition". It is significant that users share not only educational materials but also recognize common feelings or responses of other attendants.

In communication in class, responsibilities is important factor for designing system. Internet is very effective network infrastructure, however, it is still insufficient in capability and function for one-to-many type distance education system. Also, database functions are not

applied uniformly because of over concentration and personal use. Thus, there are so many technical difficulties in educational environment.

However, at the same time, there must be solutions peculiar to computer. The reason is the base of new architecture of *VIEW Classroom* . In truth, remarkably many unexplored fields seems to be remained untouched in distance education system.

Chapter 4

Presentation and Notation in Lecture

This chapter addresses the preparation, presentation, update of hypermedia documents which are presented by cooperative hypermedia utilizing object-oriented database architectures. And also from the stand point of student flexible display personalization and notation are described.

4.1 Introduction

There are various kind of learning styles, among them lecture by a teacher is traditional but most flexible means, that is, most fresh information can be introduced , mistakes in documents are easily corrected by vocal. Still more, in comparison with teaching machines, feedback speed and motivational impact is much superior. However, in conventional class setting especially mass education environment, a lot of problems to be improved are known. For example :

- Reuse of the same textbook or materials unchanged for a long term (sometimes for many years) for troublesome of updating,
- No accurate and concrete data of students' current interest and level of understanding for feedback in real-time,
- Delay of assessment for students' activities.

Actually, many colleges students in face-to-face but a large hall may often feel so isolated that they are different locations. Much less for students in distributed places and time, problems above are often fatal disadvantages. Most of all, the delay of communication appears to be most basic and important issue in nowadays distance education.

In *VIEW Classroom* , teaching materials are presented as hypermedia documents to the students within CSCW environment. The basic mechanism are provided by *VIEW Media*: a hypermedia-based collaborative presentation system [Kon95] which enables participants to enjoy interactive and synchronous teaching and learning.

Centering the instruction with hypermedia, variety of lecture styles are possible including discussion, question-and-answer (Q-A), quiz, presentation by student, student-student private chattering and so on. Discussion and Q-A are focused in Chapter 5 and 6. The following is the lecture image in *VIEW Classroom* .

Figure 4.1 shows the screens of a teacher and a student on which sharing teaching materials are shared. A teacher gives a lecture, pointing and underlining on the text, figures and images on shared window. If necessary, the teacher modifies those materials or the sequence on the spot. On the other hand, listening the lecturers voice, students face with identical materials on shared window on her/his own display and take notes (copied in note database), underlining, adding personal comments, linking with their own documents. Besides the view of screen is personalized as to window size, character size, font style, color, etc. These modification looks executed visually, however, originals are protected. The actions by teacher causes real update and reflects on students' notebooks. The teacher's and students' personal documents can be referred only in each personal field. Hypermedia implements these "Media sharing", "Virtual update", "Personalization", utilizing advanced database functions.

The process of the lecture is automatically recorded for giving a revival-lecture to the attendants after class. Also it helps the teacher to improve the materials and method of teaching.

VIEW Classroom has following principals on learning in on-to-many style.

- Learn from human tutors
- Learn from other students also
- Learn in personal leaning environment

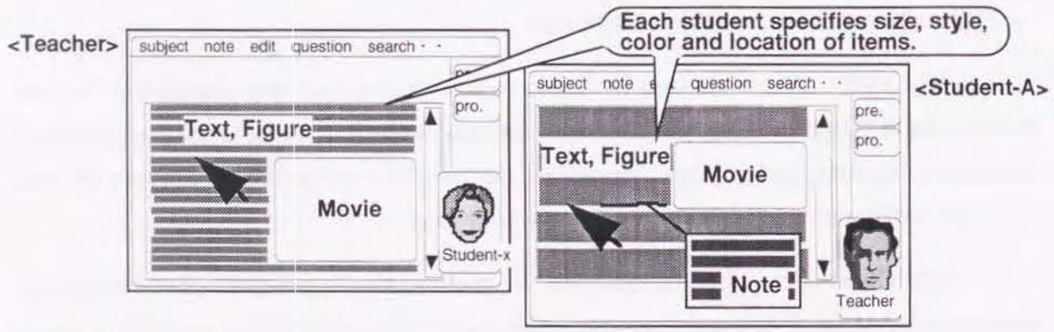

Figure 4.1 Example of the Teaching Material and Note

4.2 Presentation using Shared and Personalized Windows

Teaching materials used in a lecture are supposed to have following features on its structure.

- A teaching material is composed of (1) an unit of document (or set of units) and (2) links which relate with other units and anchors (to be mentioned later).
- Teaching materials can be applied in any educational situation such as discussion, test, assessment, etc.
- Educational materials include not only teaching materials but also student's notebooks, assignments and their assessments, tests, their results and tools for evaluation, etc. However, in this paper, teaching materials conventionally include other educational materials. Also it's often used in almost the same meaning with learning materials.

On assumption above, lecture facility described in this section include:

- Preparation of hypermedia documents
- Preparation of test
- Simulation before lecture
- Lecture
  - Distribution of teaching materials
  - Starting lecture
  - Instructing with pointer and voice
  - Controlling of student display
  - Recognizing student view
  - Monitoring students
  - Referring personal documents
  - Checking time
  - Relaying of teachers
  - Closing lecture
- Evaluating the lecture

Preparation of Hypermedia Documents

At the first stage of a lecture, teaching materials have mostly not completed, sometimes exists only a skeletal structure. Therefor, the system should presume that not only text contents are modified but also sequence or structure is dynamically changed. In particular, there seem to be

strong tendency in specialist education due to the posing of unexpected questions, special requests, or new topics, etc.

In addition to materials with scenarios for specific subjects, there are other materials with high independence for use in discussions and information exchange. Actually among colleges, universities, and educational institutions, professionals often exchange informations or teaching materials of various kind. Most of their materials are temporary stored and wait for reorganization for educational use in near future. Hereby, the architectures presented hypermedia can play a important role in making and editing of teaching materials.

Editing materials

In preparation of hypermedia documents, there exist following works after making scenario.

- Editing of texts, pictures, graphics and animations by authoring tools
- Cutting and editing of moving pictures from VTR
- Editing sound including voice
- Setting anchors and links

The detail descriptions of preparation process above are not this papers concerns, but with anchor and link should be addressed on its extended use.

Anchor and Link

With relation to the anchor, it's defined such as word, sentence, area, page, time (in case of moving picture and voice), teaching material ID, etc. An anchor can have multiple links for various purposes (attributes), e.g. structural relation such as chapter, section and paragraph and contextual sequential relation. Practically traced (sometimes modified) links in a lecture are held for reuse for a teacher to prepare for other classes and for students (included after class attendants) to trace when they review the lecture. The view of links are presented visually. The followings are examples of link attribute for a teacher.

- example • reference • drill, quiz or test • answer or comment on test
- student response • student achievement • private document or memo

Fixing of screen attributes setting

During a lecture, a teacher may be annoyed by trifle operations such as window size, position, character size on student' screen, etc. Those are of course able to specified according to the situation during lecture, however, teacher gets to know the best one empirically. Therefor,

previous fixing those attributes are decreases the load of operation and enables her/him to concentrate on the lecture. The following is the examples of such attributes.
• display layer • active/non-active • referential scope permitted for students for each theme • flame size of graphic and moving picture • sound volume

Preparation of test

Test materials are one of the teaching materials. Test is a good chance to check students' comprehension and feedback the results to students and the teacher also. However, in conventional class setting, frequented tests lay teachers overload. One execution of test requires making test materials, distribution, execution, gathering the answers, marking (evaluation), registration and announcement the results, presentation the right answers and their explanations.

Otherwise, CAI or other commercial authoring tool may be introduced. In VIEW Classroom, the sequential process of a test as mentioned above is to be support, combining the lecture and discussion mode dynamically for feed back the test results (the design is to be reported in following studies). In the test facility, from the authors previous experiences, flexibility will be one of the most specific features, since in a specialist education, test answer is not always one or sometimes unknown at worst (its proved so just in test time). Still more test contents like an expression or a value have possibilities of being modified by posing student's questions about the test. And the modification is often not only related to the answer or criterions of evaluation prepared but also to the materials to explain the answer. Therefor, flexible measures for reconstruction of test setting on the spot should be considered.

Simulation before lecture

The system presents the teaching and learning simulation environment for teacher to recognize how the teaching materials behaves. Figure 4.2 illustrates laboratory (virtual laboratory) being prepared a blackboard on which teaching materials are shown, and a student table from which the blackboard is seen, and a editorial window to edit and arrange the materials. These windows can be presented to other permitted staffs or guests who are supposed to be in the same office by moving their Person Object in the office. Teacher can try to take notes or answer test questions, sitting at the student table (the system switches to student's view). Hereby, the preparation is completed. Some teachers may have no preparation and give lectures mainly by oral instruction and type some texts when necessary. That is also one of the teaching styles.

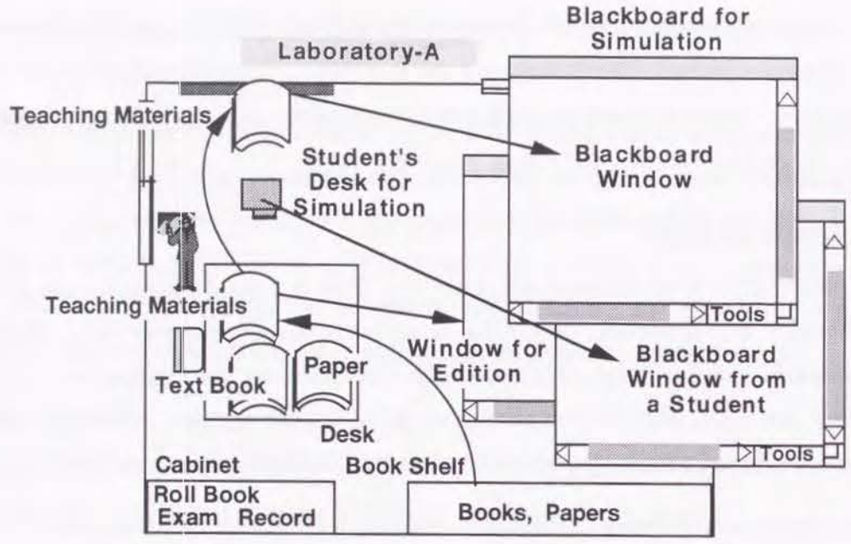

Figure 4.2 Preparing Teaching Materials

Lecture

- ***Distribution of teaching materials***

There are two ways on distribution of teaching materials. One is that each student accesses to a server by her/himself, and another is that a teacher transfer them to students' computers. When some modifications to the teaching material at teacher's site have broke, only the transaction of modification (difference) is sent and updated at students' computers to save time for transmission. Also to save response time, the materials to be used earlier take priority in sending and while they are on display, rests are followed. Figure 4.3 shows the image and also shows a classroom layout at the beginning.

- ***Starting lecture***

Teacher should start lecturing after checking that the students have received teaching materials. By moving Teaching Material Object to a blackboard area they are presented on students' screens, then teacher can check them by switching to student's view (to be mentioned later). By moving Person Object (a teacher) to classroom, she/he can start speaking.

- ***Instructing with pointer and voice***

In a lecture, teacher's actions by pointing, underlining, scrolling, navigation of windows, etc. are transmitted and work synchronously at students' screen. Also, oral instruction plays important role. The facial expression and motions are helpful but not always essential. It is also ascertain in presentations of conference system that participants pay attentions on the motion of pointer coordinated with voice. In *VIEW Classroom,* voice and pointer are synchronized and treated with high priority.

To lead audiences' eye, multiple pointing tools are prepared: arrow, underline, area selected with color and a few sizes. They can be used at the same time.

- ***Controlling of student screen***

While lecturing, a teacher sometimes need to control displays of windows compulsory. The followings are the examples which need controls.

Example 1: A specific window in high priority like a window in test mode must be displayed in front layer at the same time, prohibiting students to refer related documents or the right answer sheet. In case that end time of the test is flexible, she/he must stop accepting answers by giving a control command.

Example 2: Teacher can decide in class when some specific reference materials should be open to students. If those materials are accessible from the beginning, students may be willing to navigate them and pay little attention to instructions. Therefore, the timing is important.

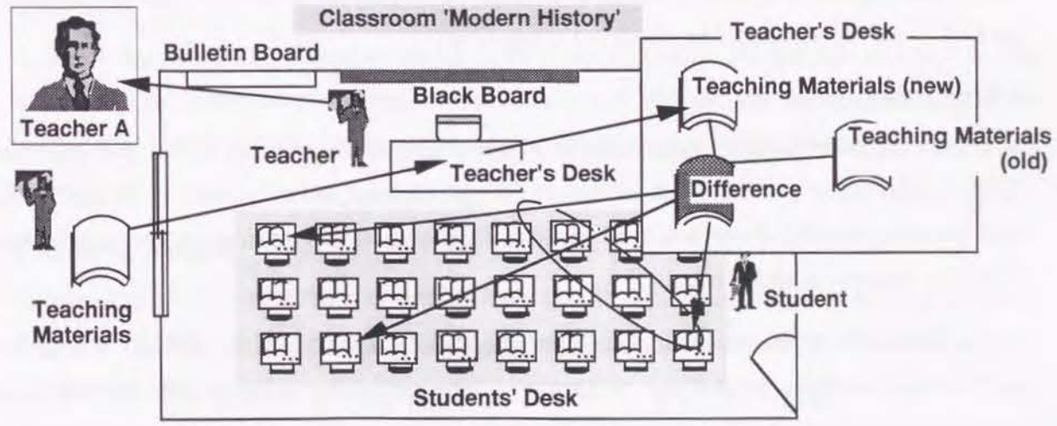

Figure 4.3 Distribution of Teaching Materials

Setting in advance or control in lecture is both possible. The control informations set in advance are transmitted to students' workstations along with teaching materials and work there in no time. Those informations are able to be changed in a lecture before students access. As an access tool to refer materials on other external databases, not only tools provided by *VIEW Classroom*, but also existing ones are available.

- ***Answering questions***

Answering to the questions is another big task for a teacher. However, in on-to-many style lecture, synchronous question-answer support is tend to be neglected for the difficulty of control interaction. VIEW Classroom gives new mechanism for interactive communication (see Chapter 6 for detail).

- ***Switching to Student view***

To recognize the student's view is very important for teachers. The main reasons are :

- To know what are student watching or doing. This is means for "awareness". If there are big differences in subjects on which the teacher and students are focusing , the effect of the lecture is naturally decreased.
- To know whether she/he is making mistakes in operation or not. In fact, some teacher did not notice that he was showing test results list of secret all the time of lecturing just because of his simple operational mistake.

In *VIEW Classroom*, the view of student is provided for the teacher on demand. Moreover, the current page distribution of students refer can be displayed. If monitor size is enough, a student's view screen should be displayed at any time.

- ***Monitoring students***

The function above supplies one means of monitoring students. In this theme, it means the direct monitoring of students faces and voices through cameras and microphones. In generally, even in traditional classroom, teachers' attention are payed on several students at one time, not on all the students attended equally.

In this distributed environment, a student image is displayed one after another (If monitor size allows, multiple images can be shown) . The switching speed is controllable, and automatically and cyclically students' expressions can be monitored during the lecture if the teacher wants. It is important point that a current target student monitored can be noticed that

she/ he is watched. In fact, the teacher may not always pay attention to the students. The most significant is to let the students know that their teacher is always concerning with them. This function is expected partly such psychological effects.

- ***Referring personal material***

Personal layer is provided for the use of displaying or updating personal material which a teacher don't want to present for students, such as lecture plan, school registration information of students, test results or attendance list, etc.

- ***Checking time***

While lecturing, a teacher often check the time casually and estimate the left time to adjust instruction pace. To help this small but frequent job, a timer can be set at some checkpoints in text. When the checkpoint is passed the timer tells the current time, elapse time, and left time with blinking.

- ***Relaying of teachers***

The person on the platform is not always the same. Depending on specialty or detailed research domain, multiple teachers can be charged in certain subject, relaying one after another. Moreover, panel discussion style also can be adopted. In traditional classroom, it is rather difficult to realize world wide lecture by multiple professionals, however, in distance education, since not only students are distributed but also teachers, the gorgeous lecture is fundamentally possible. Sometimes a student takes place of a teacher. Note that basically system structure is to be designed so.

When they exchange the lecturers seats, they can communicate and the situation can be broadcast. Educational environment is taken over to new teacher, including lecture logs. The teacher who quit is possible to stay as a student, partly possessing the function of monitoring students and others.

- ***Closing lecture***

Announcing next lecture schedule, teacher leads the class to end, actually by moving a Parson Object to outside the classroom. Although, the classroom is available for students who requested to have a chat.

Evaluating the lecture

A lecture left a lot of fortune of students' behavior which enable the teacher to evaluate and feedback to her/his lecture and material. The system collects and records all the students' specific responses at one moment but also records the sequential leaning process of specified student (student selection is dealt in Chapter 5). The following records could be clues for feedback.

- Question frequency and the contents related to specific part in teaching material
- Linking relation between teacher's and student's material
- Student notebook (needs the permission of the owner)
- Signals (brief message or short free description)
- Students chattering after the lecture

4.3 Notation and Virtual Update

In this section, notation facilities for students are main theme. The reason why students are inclined to devote themselves to take whole note is that the note is everything on which they can rely when they review later. The system should support to decrease the load of copying texts in the first place to let them concentrate on comprehension of the contents. Notation facility described in this section include:

- Taking note in note database
- Submitting question
- Customizing teaching materials
- Specifying key word
- Updating material (Virtual Update)
- Linking with existing materials
- Specifying keyword of interest
- Using buttons for play back
- Selecting materials to store
- Dialogue after the lecture
- Reviewing the lecture

Taking note in note database

The teaching material used in a lecture are distributed to all the participants. Student take note, underlining, modifying, linking with related documents, etc. The image and oral materials are also stored in each private note database which is normally prohibited to refer without permission of owner. However, the teacher is possible to monitor the note partly such as permitted documents and outline information like view of links, and location of memo.

Submitting question

Students are free to submit questions pointing question target (text components) and using question menu at any time. Some answers to the question are responded quickly by Question-and-Answer database. The mechanism is described in Chapter 6.

Customizing teaching materials

Teaching materials on student screens are allowed to customize according to student operational environment. The modifications are temporal and visual, and the attributes of originals are never updated (Virtual Update). Changeable attributes are as follows.

- window: position, size, layer, active/non-active
- character: size, font style, color, keyword specification
- figure/table: size
- moving picture: position, size, sound volume

Updating material (Virtual Update)

Teaching material can be modified according to student's interest. The differences from the original are stored separately, and composed when requested to display (Virtual Update). The update transaction sent from teacher are reflected to stale original after inquiring the student about updating with information which indicates the influence for student's modification (there could be a large deletion including student's links and anchors). Conceptual update is done like this.

original + teacher's real update + student's virtual update = visually updated material

The following are additional elements.

- underline • mark • background pattern • memo • figure/table • sound • animation

With related to update of teaching material, what has been discussed in our *VIEW Classroom* project is an issue of the copyright. Fundamentally, as the author's will must be given serious

consideration, copy and refusal of original updating may sometimes not possible.

Linking with existing material

Selecting a component of teaching material such as a text, figure, picture as an anchor, linking with related material of her/his own is possible. Student's links are independent from original links by teacher, and the relational view of linking is shown visually.

Specifying keyword of interest

If a student has a keyword of interest and specify it, every time the word appears in text, it tells the location by highlighting, brinking, and coloring. Also, related materials linked the key word is automatically displayed.

Using buttons for play back

While a moving picture is presented, play back is possible. When student move a Play Back button to the picture window, a controller is displayed in which buttons are included for play, stop, backward/ forward rewind, volume, zoom up/zoom down of picture. Moving picture is also a subject for modifying.

Selecting materials to store

The volume size of whole teaching material are often large especially it include many graphics and moving pictures. So, a student can select the materials before quitting.

Dialogue after the lecture

This is important time next to lecture from the educational standpoint. Especially, in specialist education, lecture is just the beginning or base. Through exchanging the impressions or informations personally, they learns each other far more. Therefore, the system offers after class environment also.

Reviewing the lecture

As one of the measures for after class, *VIEW Classroom* provides review facility. This theme is described following section.

4.4 Replay of Lecture by After Class Attendants

Different from traditional classroom, in distance education environment, time is also distributed factor. That is, there are many students who cannot participate in time or cannot continued until the end of lecture, so, their attendance time will be quite deferent. *VIEW Classroom* considers facility for after lecture seriously not only for attendants to play back the lecture but also new attendants after class to learn almost equally. In order to realize review after lecture, Review Facility is offered which specific features are described below.

Automatic recording of lecture process

The process and used materials are automatically recorded unconsciously for a teacher and students.

Browsing the lecture

In case of an attendant at lecture, real time review is not necessary, so, the system provides following measures for the lecture overview by browsing.

- Specified page, part (chapter, section) or region (paragraphs, etc.) in text list are presented as pointer-less and voiceless document. If needed, real-time lecture within the limit of the scope is given based on lecture record.
- Specified text component such as term/figure/picture/ etc. from list is retrieved being shown highlighted and with a related explanation.
- Specified question in Question Menu is answered automatically, using Question-and-Answer database.

After class countermeasures

Different from a lecture in class, the remarkable disadvantage for after class attendants is that there is no teacher who answers directly and a little chances of communicate with other students. However, they can enjoy the lecture and notation equally with the students in class. Fundamental services are as follows.

- Distribution of teaching material

  Up-to-date teaching material is provided from server.

- Lecture and notation

  Whole lecture review based on the real elapse time is possible. However, some may make

use of browsing function.

• Question and answer

Question can be submitted in after class. The similar question has made and answered in class, the answer is given quickly. However, the system recognize a new question, it is sent to the teacher, and if she/he is lucky enough, answer is given later by teacher or other students because after the lecture teacher can register new questions to bulletin board for answers.

• Students' responses

Students' posing such as " Difficult"," Pace is too fast " (these brief messages are iconfied) are accepted and sent to the teacher as one of the after-class- informations. Learning pace may be controlled easier than in class because the presentation speed is adjustable by replaying the lecture process recorded.

With detailed students' response and question-answer are described in Chapter 5 and 6,

4.5 Structure of Educational Materials

Teaching material dealt with in *VIEW Classroom* has specific structure in which material and link are managed separately in database.

Structure

Teaching material is composed with element, cell, and link. Educational material object such as a text, figure, moving picture, and evaluation tool is regarded as an element. As seen in Figure 4.4, cell is a set of elements or a set of cells. A element and cell is related with one or multiple links, belonging to other elements or cells, while root cell doesn't. Link is another object differs from cell and element.

Link and the Rolls

Elements include not only prepared materials by teacher, but also notes and materials made by students. Lecture is a tracing the links in a sense, sometimes being modified dynamically. Link is classified according to the objectives for use. Following is the typical examples of linking.

- **Static relation**

  Generally, text documents are linked based on the table of contents. In this case, links indicates static relation between documents. Some personal memos can be included which are

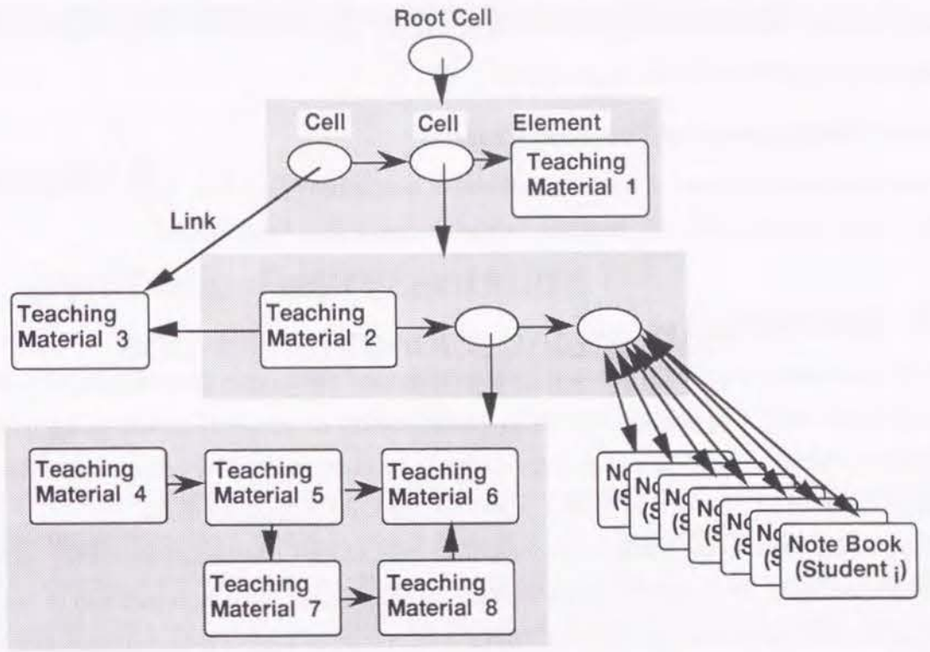

Figure 4.4 Structure of Teaching Materials

only referred on personal region.

- **Presentation order**

  Adjusting the class level and lecture time, presentation order of materials is often changed. This type of linking is set on the planning phase.

- **Actual lecture record**

  Still more, actual presentation order in lecture is changeable. This trace-history data is stored to enable students to review the lecture.

- **Notation related with teaching materials**

  This type of links are set by student to relate with their notes and existing documents.

Visual Link Structure Representation

To know how the objects are linked, overview of link structure can be displayed visually, changing colors for each purpose.

Access Limitation

Element, cell, and link can have limitation of access. Therefore, personal objects for a teacher

such as lecture plan, student registration information, and their achievements, and also for a student such as personal note are protected.

Phased Development of Teaching Material

For a teacher, development of teaching material is a quite heavy burden. Therefore, the flexible measures for accumulation of materials through lectures must be delighted.

4.6 Summary

This chapter described the facilities of presentation and notation in distributed environment. Specific features of hypermedia such as cutomization or personalization of hypermedia documents, views on screen, and operations are to be implemented by collaborative database system VIEW *Media* for which *VIEW Classroom* has been making requests.

Adding to the basic hypermedia environment, in educational conditions especially in on-to-many lecture style, other specific features must be considered. That is, regulation of students' operations or environments by a teacher, which is important as well as independence, flexibility, or personalization. Currently, some hypermedia systems based on database has in use, however, they don't consider the control of students' screens such as opening or closing specific window at the same time, or prohibit or permit of students' reference or navigation dynamically during lecture. These controls should depend on teacher's strategy. This system tries to support student's strategy, however, teachers' (especially of colleges and universities) educational techniques are not only diversified but also not opened to public. Furthermore, techniques are likely depend on the physical and human resources in an educational institution. These are the reasons why designers feel difficult in proposing detailed and concrete specifications and many conventional education systems have still remained to provide means such as authoring tool, class management tool, or insufficient communication tool.

Through the analyses and design described in this chapter, the author recognized repeatedly that there are too many necessities and possibilities for supporting dynamic teaching-learning processes in class. In near future, according to the development of educational technology and computer infrastructure, there need to reconstruct the facilities of *VIEW Classroom* , however, the strategy of strong support for teachers' strategies is never changed.

Chapter 5

Symbolic Representation and Synchronous Interaction

This chapter presents two techniques VIEW *Classroom* supports. One is for the symbolic representation of students' status to inform teacher of the attendants' responses to the lecture. And another is for the synchronous interaction in group activities like a discussion. This chapter might be said the core of this paper since the specific feature of *VIEW Classroom* , on-to-many style education and symbolization of a mass of student's response are described.

5.1 Introduction

At the beginning, a few issues should be reconfirmed related to this chapter's theme.

Issues

Large distributed students

This distance education system assumes a large number of students in a class (of hundreds) because one-to-many style lecture base. In classroom, members are free to login or out, that is teacher has no reliable static information concern with currently attending students. So, the system should be constantly sensitive to give a information requested from teacher and help to decrease the burden of charging in big class.

Recognition

In a face-to-face classroom, teacher is easy to catch students' responses and in no time tries to reflect on her/his lecture. In a distributed environment, however, because of the potential large number of attendance as mentioned above, it is fairly impossible for to catch the students' status. They may be feeling difficulty in following the lecture or sleeping or away from computer. Due

to a display size, teacher cannot show all students' images at the same time. While, also a student can't recognize other students' responses and achievements and still less share sympathy with others. In such situations, after long period, the motivation for learning might be decreasing.

Therefore, other computer-supported mechanisms are necessary for presentation and recognition of students' status.

Synchronous interaction

Currently, transmission rate is so insufficient for real synchronous interaction that time delay must be considered at any situations for a period of time. Beside students' transaction peek is hardly predicted for time difference, system must be designed to distribute the traffics.

Discussion is essential activity in higher education. However, in distributed environment, significant interaction support in on-to-many discussion have not studied.

Support by *VIEW Classroom*

Symbolic representation of students' status

VIEW Classroom provides the facilities of to record students' mouse operations (e.g. underlining, annotations) or other responses and present in symbolic manner on teacher's window (and students' windows if necessary). This representation will lead to reduce the quantity of the transmission.

As a representative frame of symbolic representations is "student-seat-map" which represents a virtual classroom and the component is student's desk which is colored or changed in shape according to specific status or condition. The advantages of this representation are:

- natural representation for student recognition
- easy to select a student (by cricking a desk)
- assuming a desk as a group, multi-dimension map can be installed when the class is growing

One-to-many synchronous interaction

To discuss with students in distributed locations, teacher has to select one (or a few) student as a communication partner from many unknown students. *VIEW Classroom* helps teacher to select candidates under various conditions. And a teacher and the student begin discussion

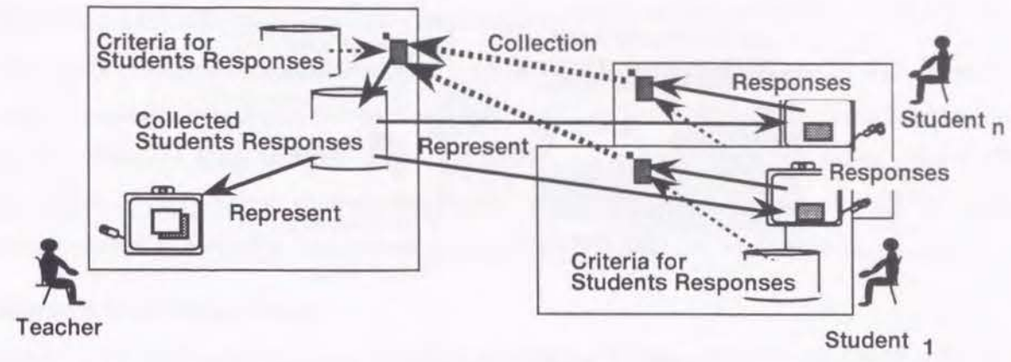

Figure 5.1 Concept Image of Students Responses Representation

using their pointers on teaching materials on a shared window. They are faced with each other through image windows listening the voice from speakers.

Discussions in "one-to-many" style is executed in an interactive environment. This means that the system constructs the environment so as to make the speakers in discussion feel the existence of audience. For that purpose, the system broadcasts the discussion to all participants. The audience are allowed to send agreement or disagreement signals or opinions at any time. Those responses are shown to speakers in real time. Teacher can select partner from voluntaries who have appealed by sending new opinions. This discussion style is the "one-to-many" interactions in *VIEW Classroom*.

Thus, given chances of participation in group activities, students must be encouraged for more learning. Trough such discussion, teacher can lead them to make several groups with similar interest and to get certain results from new discussions. The teacher-support -facilities are also available for group leaders within the limits.

5.2 Symbolic Representation of Students Status

VIEW Classroom proposes symbolic representation as one of the measures for examining the status of specific person or group, and also for taking a global view of whole class.
In this section, the symbolic representation is illustrated in following sequence.

(1) Sending a Signal (message) to Teacher
(2) Collection of Signals

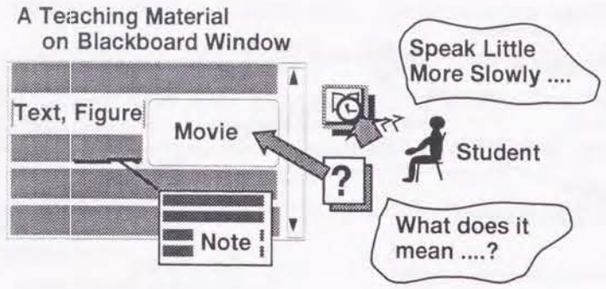

Figure 5.2 Sending Student's Impression

(3) Semantic Classification of Free Descriptions
(3) Evaluation of Responses
(4) Symbolic Presentation on Response-Map
(5) Sending a Request from Teacher
(6) Reevaluation for Next Class

Figure 5.1 shows the process of responses until presented to teacher.

Sending a Signal to Teacher

The system provides means of sending a signal like a brief message on impression of current lecture. It may bring a vital and effective lecture. However, if the system requests students burdensome operations, it may detract from students' voluntary signals. Simple operation is the key of system.

In *VIEW Classroom*, students send a message only by clicking the icons presented on window in which teaching materials are presented. Teacher can prepare standard icons which means typical impression such as " interesting", "difficult", " too fast pace", "give me time for note" , etc. If necessary, other icons or templates on extended windows are available. Icon layout can be changed for frequent use. Student who wants to send personal message may open the window to write down the text, or modify template. A relation-free signal such as "Let's have a break", "I'll quit soon" is sent by single click on the icon. While, as to the contents related with a special part of teaching material, the operation is only dragging the icon or personal message window to the target location in material.

Semantic Classification of Free Descriptions

The system provides the tools for users to write messages through keyboard. Problem is that if a lot of messages reach at a teacher directly, she/he can never read them through during the lecture. Therefor, some interference are requested to summarize those messages. The *VIEW Classroom* has a semantic analysis mechanism to classify different message texts into some groups of slimier contents. Typical contents can be registered as templates or icons later.

Evaluation of Responses

Ordinary, student's underlining to teaching materials is supposed one of the criterion of their level of interest, concentration, learning pace. For example, two locations of teacher's pointing and student's underlings are near, it's supposed that the student is engaged in the lecture. If not, different pages are referred for example, there are possibilities that the student do not lean toward the lecture. There is another assumption that the more the location gap is big, the more the teacher's instruction pace is unsuitable. Students' mouse operations show their another cognition to the lecture, being different from conscious activities like clicking specific icon or message description . Other scales of students' interest or concentration are;

- location of annotations or anchors
- page number referred
- mouse operation
- time delay from teacher's activity
- windows in active

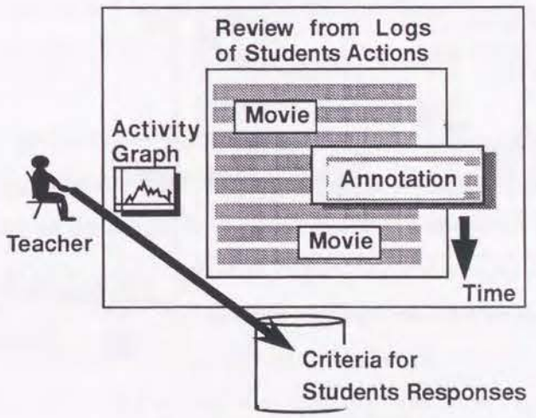

Figure 5.3 Evaluation of Students Responses

Symbolic Representation on Response-Map

Figure 5.4 illustrates the mechanism of response representation. The feature of responses are changeable time after time. The system presents the shifting process in abstracted manners laying colored dots on a transparency sheet or side belt (field) on the teaching materials. The style is selective. The system can broadcast the condition to all the students. If the teacher accepted many alarms, some measures may be taken immediately.

Even in usual classroom, teacher hardly know that his/her lecture and materials are appropriate for the students attended. Thus, *View Classroom* aims to give teacher reasonable feedback information of every class for improving lecture and materials. And also it enables teacher to recognize what significant features a student or class has .

Sending a Request from Teacher

Notice or question from teacher to students are mainly conveyed with voice. However, text messages are sometimes more effective to confirm the contents. When teacher clicks some icon, a message is shown onto the students' windows like "Attention !", "Time is up" or sometimes requesting a selection of an answer like "Yes", "No" or some messages from the

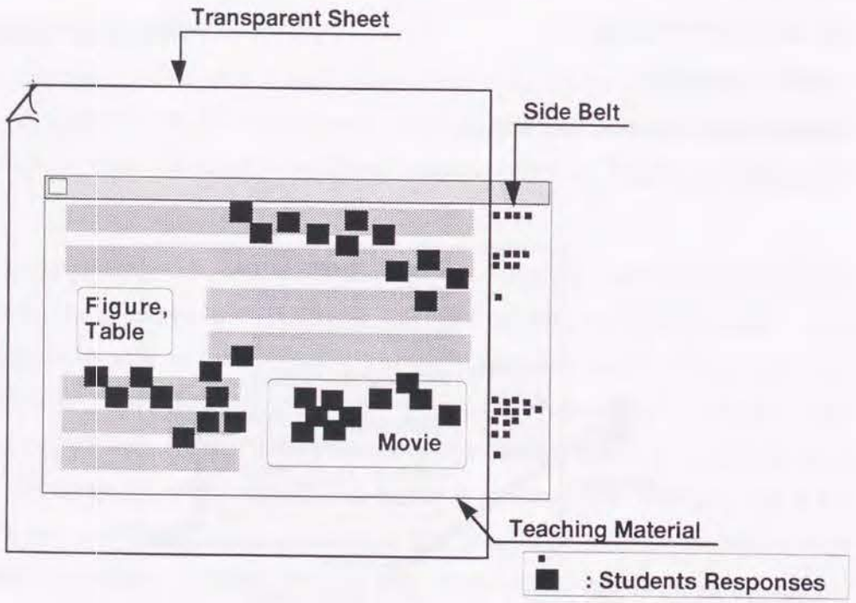

Figure 5.4 Response Representation

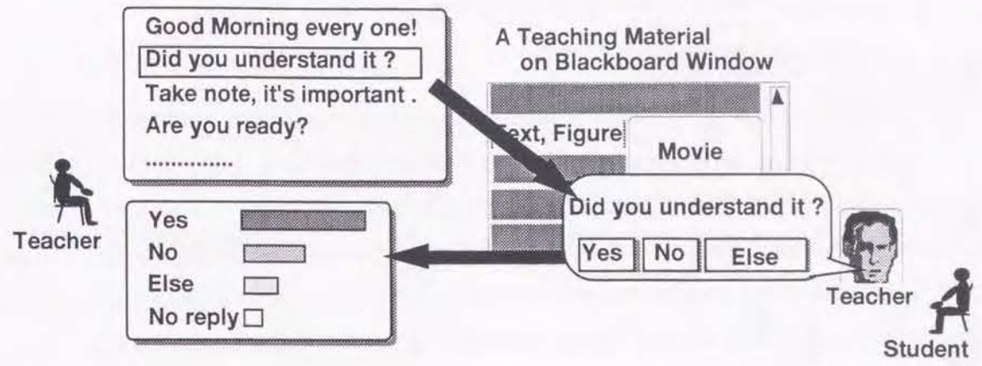

Figure 5.5 Sending Request from Teacher

teacher. For a notice or question related to specific location in teaching material like "Take note" or "Have you ever heard this topic?", the system provides two tools for teacher as to relating the question and target material. One is copying materials to message window, another is linking with the object.

Reevaluation for next class

Due to the large quantity of collection data and the limitation of display size, it's may be impossible to catch status of whole class at the first lecture. However, there is some means are remained to extract the essence of students' response. This implementation might be quite difficult, though, *View Classroom* proposes one method of "selection of a representative student".

After class, teacher can examine responses from student action records and evaluate some specific students' activities, and take it as whole class tendency. The detailed ideas are described below.

- **Selection of representative student**

Reviewing and examining student action records, some specific students for example who was most active in mouse operation, who posed questions most or who had good exam results are picked up (this support is presented in Chapter 6). The conditions are based on the teacher's strategy for lecturing. After that, teacher registers the representatives and their activities as temporal standard criteria. During lectures, teacher only receives or monitors those students responses or activities. First criteria may not be proper, however, this style looks very simple and attractive. Through repeated reevaluation, the criteria can be improved the precision. And

more, relations with levels of understanding or interesting can be obtained.

• **Extraction of students' interest**

If teacher wishes to know the students' tendency of interest in the lecture, material or topics, that can be shown. For example, teacher may focus on students' time delay between teacher's pointing and students' underlining, the distributed page referred at one moment (wide distribution means loose attention) or the topics underlined mostly. As described in this section, VIEW Classroom offers teachers strategic lectures with combination of the functions, sharing common environments by abstract representations as a virtual classroom.

5.3 One-to-Many Synchronous Interaction

In this section, synchronous interaction in discussion is illustrated by following sequence.

(1) Selection of Student(s) under Specific Condition
(2) Symbolization and Representation on Student-Seat-Map (virtual classroom)
(3) Discussion Using Shared Window
(4) Broadcast Discussion to Audience
(5) Sending a Signal to Speakers from Audience
(6) Representation of Audience' Responses
(7) Posing Question to Audience
(8) Recording of Discussion Process

Selection of Student Under Specific Condition

A teacher should have strategies especially for selection of a student, since we know in many cases random selection results in waist of time. *VIEW Classroom* offers not only general information of students such as the record of exams, attendance but also operational information of that day such as the frequency of questions or notation. Thus teacher can assign a student imposing some conditions like "student who had most frequently underlined ", "student who has never discussed with" and so on. These strategic preparation is recommended to prepare before class. If there are a large number of candidates in classroom, weight can be given or changed to condition.

On the other hand, students' active participation in discussion must be allowed, inviting to register her/his name with a brief message on motivation or viewpoint. The system offers information as mentioned above for applicants and includes them in candidates.

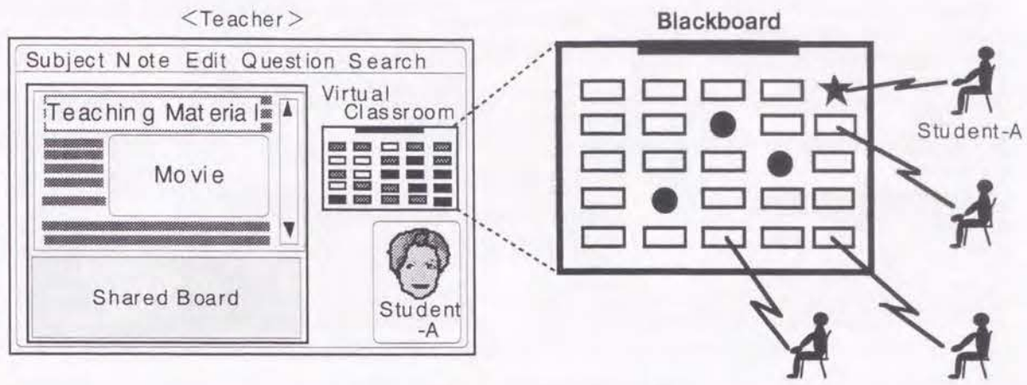

Figure 5.6 Studen-Seat-Map (Virtual Classroom)

Symbolization and Representation on Student-Seat-Map

As Figure 5.6 shows, the selected candidates are shown on a student-seat-map (virtual classroom) where student is represented as a small rectangle (desk). A virtual classroom that shows virtual seats of students are also useful for teacher and students to address a specific partner. She/He are identified by specific colors and patterns according to conditions. Attributes of the representation to be displayed are as follows;

Status: A pattern represents a condition or situation of student. For example, the system shows the students who's average record of exams are over 90 by using a "circle" for example. Additionally teacher imposes another condition, another mark is used.

Priority: Priority is represented by color and brightness. For example, in the order of red, orange, yellow, priority is getting higher. Values to determine priorities are determined by weighted summation of conditional values.

The target student's information (e.g. name, profile with a face in photo and operational logging data) is given by clicking the desk on the student-seat-map. Then discussion is set in by cricking start button.

Discussion Using Shared Window

In a distributed environment system, discussion support is so delicate as assignment of speakers. Here, some characteristic topics concerned with interactive presentation, grouping, awareness, cruising (monitoring) around students/groups are explained.

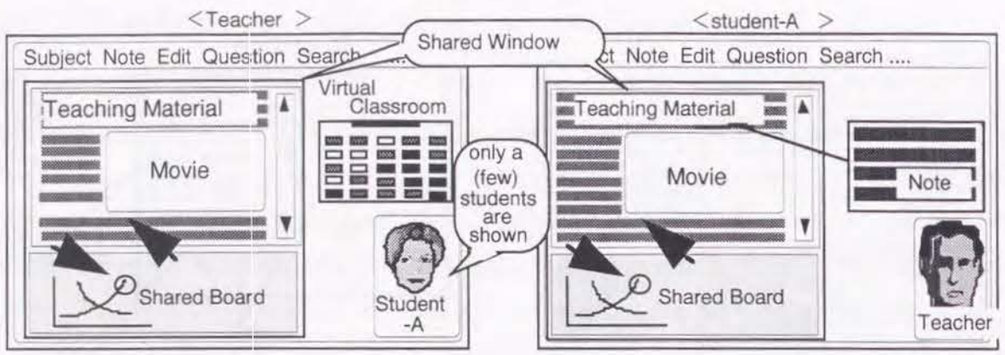

Figure 5.7 Shared Windows

• Shared window and personal window

Figure 5.7 shows shared window which is open to whole class where teacher and student discuss presenting, pointing and underlining materials. Presenter can open some shared windows if necessary. On the other hand, they often become necessary to take a brief look at personal notes or documents without presenting on shared window. Those can be referred individually in personal window which is hidden from other participants.

• Change scope of widow sharing

Presenter have various documents for discussion. Some are (1) definitely personal, (2) sharable only with specified persons (including teacher) or groups and (3) open to all participants in the class. Student can change the attributes of sharing scope in dynamic according to the role of documents.

• Grouping

Grouping students under some categories on some student attributes, the record of their activities or interest is possible in *VIEW Classroom*. using the function of selecting student as mentioned before. The system prepares new virtual cabinet for each group that has a conference table and some communication tools.

• Cruising

Teacher can cruise around students or groups, listening to their opinions, giving advice or evaluation for their achievements. While teacher is cruising student is informed of being in target. This is one of the realization of awareness and gives students similar effect like eye-contact in real classroom.

Broadcast Discussion to Audience

The system broadcasts the process of discussion showing shared windows, interactions by pointer and underline with aural instruction. Though audience are permitted to write in the shared window, they are free to link the presented documents to their own notebooks. This is one of the representation of "one-to-many" interaction.

Sending a Signal to Speakers from Audience

Not only in lecture but also in discussion, the audience can send some signals by pressing a button meaning "Agree (or Disagree) with A/B" (A, B are persons who are engaged in discussion and shown current speaker) or "Another opinion" which requests the student for free description. The system collects these responses and send to server where summarize the data and present by certain interval time.

Representation of Audience's Responses

Under current level of transfer rate, perfect synchronous support is hardly implemented because of time delay. Never the less, there exit some ideas. One is a representation by time series graph showing the number of agreement with A, B and others. Another is a symbolic representation by student-seat-map where audience's responses are reflected using color (e.g. blue is meant agreement and red is disagreement). Student-seat-map need to be multiple so as to identify the speaker and most interest map is displayed in front. Those abstract representation are selectively shown on audience's display, if necessary. To use those representation effectively, they should be simple and visual. Further discussion may be requested on such styles.

Posing Question to Audience

On the way of discussion, speakers may take an interested in other students' responses on specific topic. In such a case, they can pose a question requesting "Yes" or "No", or present some choices like a quiz. In author's experience, this frequent use functions very effectively for attracting audience's attention and analyzing their interest.

Recording of Discussion Process

The system records the process of discussion as a part of the lecture to be reviewed. For some specialists, this record might be more attractive than documents themselves.

As described above, "on-to-many" interactions in class are open to new way to active

participation to group learning. There seems to be more attractive interaction not only between teacher-student but also student-student which is private chattering or exchange information during lecture. The diversity of learning style is one of the characteristics of *VIEW Classroom*.

5.4 Structure for Supporting Interaction

In this section, specific structure of *VIEW Classroom* for supporting interactions as we have seen previous section.

Issues

In an interaction support system, "responsibility" is the most important subject to be discussed. Most of students annotate and link to teaching materials simultaneously with teacher's explanations. These operations produce distinctive features of education support system that has large difference of traffic between normal time and peek time. On the other hand, in a classroom, there will be also heavy concentration of communication on teacher. How to decrease these load is very important to design of distributed education environment system.

Solution

Some solution was in fact referred previous section. Replacing video by symbolic representation contributes for reducing large amount of data transmission. Criterions for evaluating student operation is sent to students' computers and work there. Furthermore, even if some responses data have delayed in reaching, the system takes a measure, attaching the time of sending or receiving to message and reorganizing the presentation order by the information. However most remarkable feature is the structure for supporting interaction.

Distributed structure

VIEW Classroom have "distributed structure" and make it possible to realize an interactive type lecture which has a large number of students.
In this system distributed structure is composed of two object types: "function objects" and "kernel objects". The function objects which display windows are synchronized each other by way of kernel objects, while the messages between teacher and students do not always access a server.

Figure 5.8 shows the relations and data flow among objects to support interaction. Teacher

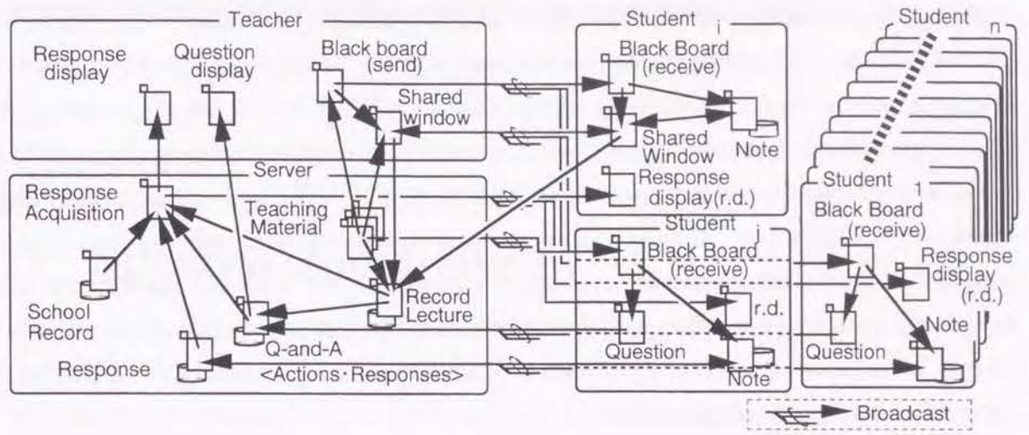

Figure 5.8 Relations between interaction support objects

and students share the teaching materials using a "black board object", generating their own notes. "Shared window object" presents a window for them to point and annotate each other. The system records these activities and conversations to a "record lecture object" for all participants to review the lecture after class.

The traffic concentration level of conversation is evaluated and controlled by database architecture and kernel object via network. Hereby over concentration of traffics will be avoided and in most case response is realized almost in real time.

5.5 Summary

Symbolic representation which gives teacher informations about students' status in visual way is expected following advantages.

(1) representation of mass data

(2) adoption to display size

(3) data transmission reduction

In this system, as a frame of symbolic representation "student-seat-map" is used where each seat is represent a student and identified by colors and shapes when a specific condition is fulfilled. Through this map, a status of whole class is overviewed.

While, synchronous "on-to-many" interaction have suggested many possibilities of computer assistance for communication in cooperative work. Today, most of existing distance education systems take "one-to-one" communication style like E-mail based system which offers asynchronous communication. Practical experiences through those systems tell the strong needs of interaction and synchronous communication. *VIEW Classroom* proposed many interaction in discussion. Audience can participate in the discussion by sending a signal (message) of impression or appealing for joining to speakers at any time, and also they can link presented documents by speakers with their own notebooks. Interactive cooperative teaching-learning environment system have just started. There are a mass of issues, however computer can do more best for assisting learners.

Lastly, the author would like to present a lesson learned from a system development and management of this kind. That is, every where there are surely some people who never feel comfortable nor disgusting toward sensitive and interfering computer systems. Some teacher might decline to give a lecture in computer-assisted environment, preferring traditional one. Some might stick to used system like E-mail or WWW base. In such a case, the system should have some means, for example, of reduction of facilities by some phases or camouflage pretending to be a simple Internet server. The future environment system should be so flexible, if expects long life.

Chapter 6

Question and Answer

Due to the technological innovation of computer network, communication between a teacher and students in distributed locations have been amazingly improved. Especially E-mail has made great contribution to global networked communication and E-mail-based education system has become a trend of today. However, little studies have been given to support of synchronous question and answer (Q-A) in large class. In this chapter, facilities for supporting Q-A which is one of the representative interaction styles in classroom are focused. Basic concepts and techniques are succeeded from previous chapter.

6.1 Introduction

Issues

VIEW Classroom offers a flexible communication environment where students are quite free to ask questions in a lecture, even if the teacher is just engaged in explaining. Therefore, questions are likely to be a large quantity. The expected issues in a conventional classroom with Q-A are as follows:

Issues of student

(1) Delay in getting an answer to question
Questions should be accepted at any time and should be answered as soon as possible. However, under a condition of excessive concentration of questions on teacher is also expected, as the results the delay would be magnified.

(2) Puzzling in posing questions
Question at the beginning is likely to be so unclear to describe. And the hesitation prevents

students from submitting questions. So, many questions in vague are remained unanswered.

(3) No room of typing question contents
Even if student could have a clear idea and make the description on certain question. They might feel troublesome in typing text for question every time during lecture.

Issues of teacher

(1) Limited number of questions that can be answered
Practically, the number of questions in a lecture is constrained by the total time of the lecture. Even in a computer-assisted system it is usually impossible for a teacher to answer all the questions. Thus, many potential questions might be ignored.

(2) Difficulty in selecting relevant questions
Teacher can never foresee the details of questions until she/he connects a questioner and ask more about the content. Since this conventional Q-A method strongly depends on an individual, it has an inherent disadvantage that important questions are sometimes ignored.

(3) Repeated similar questions
Teacher often has been charged same lecture multiple in a session or every year, thus has to answer similar questions repeatedly. To reduce this burden, similar questions/answers have to be reused.

Solutions

The issues above are not so specific for distance education, however, most existing system have not covered. Therefore, more concrete and practical analysis and measures are expected. The following have been discussed in *VIEW Classroom.*

(1) Text-oriented question
Even if a question is not so clear to tell, it might be possible to indicate the area in teaching material like a phrase, figure, and table at least. Therefore, operation of submitting a question should be started by pointing the target directly. Text typing could be omitted in such a case.

(2) Selection of slimier question from database
The system offers mechanism of classifying questions by similarity using the locations students specified and storing in Q-A database after getting an answer. This mechanism

enables student to select similar questions from menu and save typing similar text.

(3) Automatic answering
When a student submits a question already answered, the system replies the answer immediately. It partly solves the problems of limited number of questions can be answered, delay in answering question, and repeated questions.

(4) Extracting questions teacher wants
Counting the similar questions and listing in order of the numbers of frequency, or giving weight to important words or phrases, questions most students wish to know and desirable questions for teacher could be easy to get.

(5) Answering in interactive environment
Especially for higher education, a question is often developed further. Therefor, interactive communication and presentation facilities should be introduced to Q-A situation.

6.2 Model for Question and Answer Facility

Question - Answer facility is based on interactive communication model and structural model of question formation.

Synchronous and Asynchronous Interaction Model

The specific feature of this model is illustrated as a model which transits between synchronous (following the lecture) and asynchronous situation.

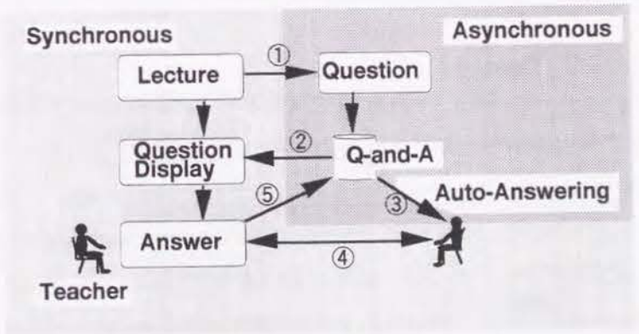

Figure 6.1 Synchronous and Asynchronous Interaction Model in Question- and-Answer Facility

Figure 6.1 shows a basic communication model in Q-A facility. In class, teacher gives a lecture pointing or underlining, and students follow the lecture annotating and underlining in their own way. This is basic synchronous interaction. At the moment a student has posed a question, he falls in a temporal asynchronous interaction mode (Figure 6.1 ①). In the case of new question, it is classified by similarity of contents and sent to teacher (Figure 6.1 ②). When the system has recognized the answer to the question has been finished, the answer in Q-A database is replied automatically (Figure 6.1 ③). Acknowledging the questions from students in question list, teacher selects a question and start answering. Sometimes teacher asks a questioner for more detail or hold a discussion. All about the process of answering (from selecting a question until ending cue is submitted) is broadcasted for all the students in the classroom. This is synchronous interaction mode (Figure 6.1 ④). The questions and the answers are stored in Q-A database for reuse (Figure 6.1 ⑤).

Allowing students transition from synchronous and asynchronous mode during lecture, Q-A database would be growing up and automatic answering is improved its probability. Note that the process of the lecture while the student omitted in asynchronous could be recovered, therefore student can catch up with in class if lost time is small, or send a signal to the teacher asking for a break a little while (many requests of same kind might prevail over the teacher) or can review after class.

The synchronous-asynchronous interaction model could be applied not only for question-answer model but also for many other situations in cooperative work in distance education.

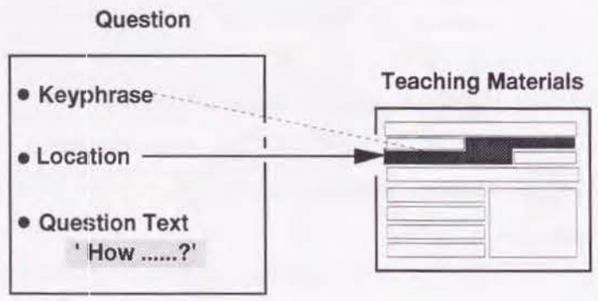

Figure 6.2 Formation of a Question

Formation of a Question

To realize the classification and automatic answering, the substance of question has to be specified. Figure 6.2 shows the formulation of a question which is composed of "Keyphrase", "Location" and "Question text".

Keyphrase: The target of question must be pointed in teaching material shown in shared window. Keyphrase could be a word, phrase(s), a picture, a table, and image.

Location: Keyphrase's location with which the keyphrase is identified.

Question text: Question content described in short sentences freely.

A question is identified based on the keyphrase's location in teaching material even if the same keyphrase is doubled. That is, the system judges questions to be (almost) the same keyphrases when one of the following conditions have been satisfied.

(1) The questions contain the same keyphrase.

(2) The locations are almost the same. That is, locations overlap each other with the number of overlapped characters is greater than a certain number.

6.3 Handling Questions and Answers

In this section, the facilities of *VIEW Classroom* for handling questions and answers (Q-A) are described referring user interface.

Overview

Figure 6.3 shows the flow of Q-A in *VIEW Classroom* which is divided into following three phases:

Phase-1: Question-proposition support for a student

Student may point a key element such as a word, prase, figure or image on teaching material as a target of question. Then the relevant question menu is shown, and proposes to select similar question if any or to type in new question contents. Question menu is possible to include the question teacher has registered. The merit is that student could submit a question on the primitive level of understanding because question contents can be " I can't understand".

Phase-2: Question-selection support for a teacher

Questions in the same category are classified into groups, counted and sorted in database in

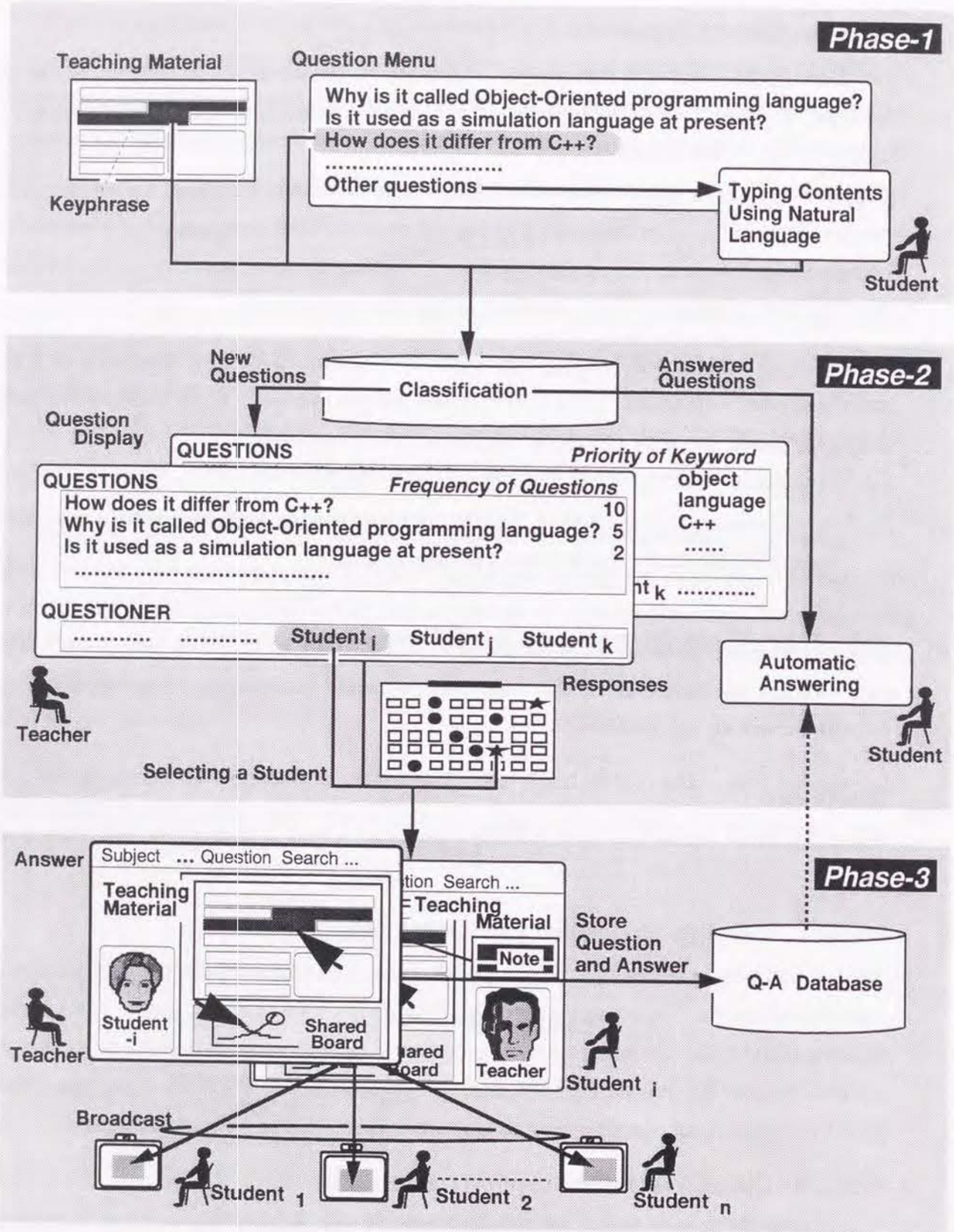

Figure 6.3 Flow of Question and Answer

descending order by the number of questioners, and then presented on teachers display as a question list. On the other hand, free description student type in are analyzed semantically and combined with used questions and answered automatically or sent to teacher for answer. Teacher select a question normally from the top of the list which are offered in two type: list on frequency of the question and list on priority by weight specified by teacher.

Moreover all the process is broadcasted to other attendants, as stated above, the answers for similar questions not presented by student will be almost settled. The question contents and interaction process are stored for attendants after class to hear the questions and answers.

Phase-3: Selection of a questioner and starting discussion

If necessary, teacher may select a questioner from name list at random for more detail of question, or select from student-seat-map under specific conditions for discussion.

Through this chain of facilities *VIEW Classroom* presents a teacher easily selection, speedy answering and a view of students' interest which might lead teacher to take feedback to the lecture rapidly. And also for students this system might give courage of asking more questions.

The facilities of VIEW *Classroom* are divided into two parts: (1) Question Support Facilities and (2) Answer Support Facilities.

Question Support Facilities

The contents below are equivalent to Phase-1 in Figure 6.3. Phase-1 includes specification of question,

Question menu for a student

When a student wants to pose a question she/he must indicate a keyphrase as a target of a question at first hand.

Figure 6.4 shows an example of a "Question menu" that is related to the keyphrase and displayed just after selecting a keyphrase like "smalltalk" (a word in this case) and then selecting the question like "How does it differ from C++ ?" from the menu. The questions presented in the menu have submitted by another student and already answered by the teacher. This menu saves their time of typing if similar answer has been answered. If the student wishes to type another question text, she/ he can selects the button " Other question" then a window for input is displayed. The input text is limited in length at present stage resewn for window size and avoid

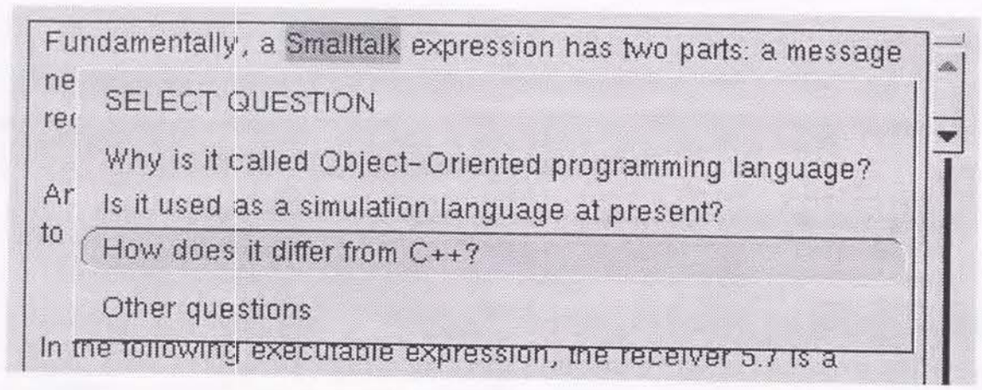

Figure 6.4 Question Menu

complex grammatical and semantic linguish analysis.

By selecting "Start Button", the question is submitted. The answer is immediately given, if the question and corresponding answer has been stored in Q-A database. If not, the question is sent to teacher, being calcified.

Personal question window

Student may update or delete her/his own questions through a Personal Question Window before teacher answers to the question if she/he has found the answer by her/himself.
Figure 6.5 shows an example of the window which displays a keyphrase and selected question in "Question Menu" in Figure 6.4. The "DELETE" button is to delete questions. If there needs to update questions, deletion must come first and then new question can be followed.

Answer Support Facilities

The facilities are for teachers and the following contents are equivalent to Phase-2 and Phase-3 in Figure 6.3.

Linguistic analysis for classifying questions

For *VIEW Classroom*, an adoptive natural language interface has been proposed [WKK96a] [WKK96b] [WKK97] so that the students can formulate their questions directly in natural language (Japanese). Those include three main steps : (1) *Morphological and lexical analysis,* (2) *UVL (Unknown Value List)-analysis and spelling error correction*, (3) *semantic, syntactic*

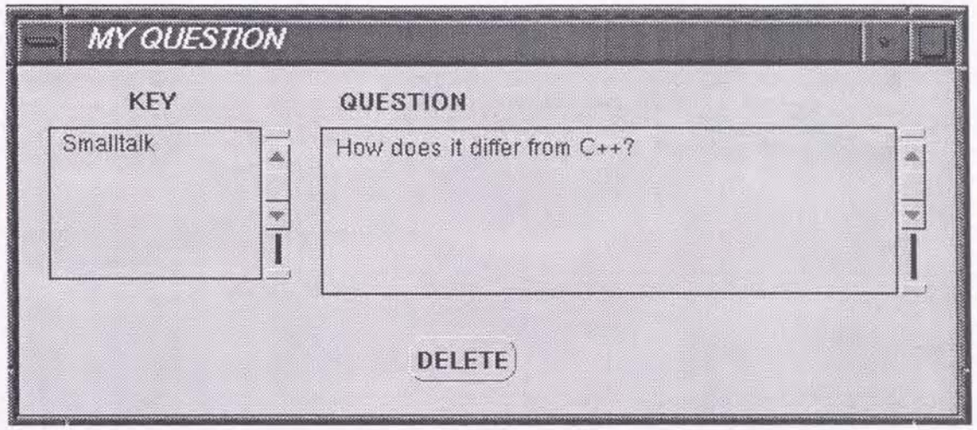

Figure 6.5 Question Window

and pragmatic analysis.

The language engineering is performed in an integrated framework by utilizing deductive object-oriented database technology. The results are sent to teacher for later processing.

Question window for teacher

The system presents two question lists, one is ordered by the number of students who submit questions and another is ordered by higher priority set by teacher. There are various types for answering. Teacher can:

(1) select a question from question lists normally from the top of the list. The answer is made by typing a text (this can be linked with students' notebooks) or by speaking to a microphone.

(2) select a student from "Questioner" which is presented after selecting a question for asking detail of the question. That is, the starting of discussion mode as described in Chapter 5.

(3) select a student from "Student-Seat-Map" under the some conditions.

Figure 6.6 shows an example of Question Window for teacher. Conventionally the data in fields are all shown at the same time. The fields in the window have a meaning as follows:
MONITOR : Question texts are displayed. Teacher can recognize the situation through multiple current questions displayed in the this field.
KEY : Keyphrases which questioners selected are shown. This filed serves the most simplest

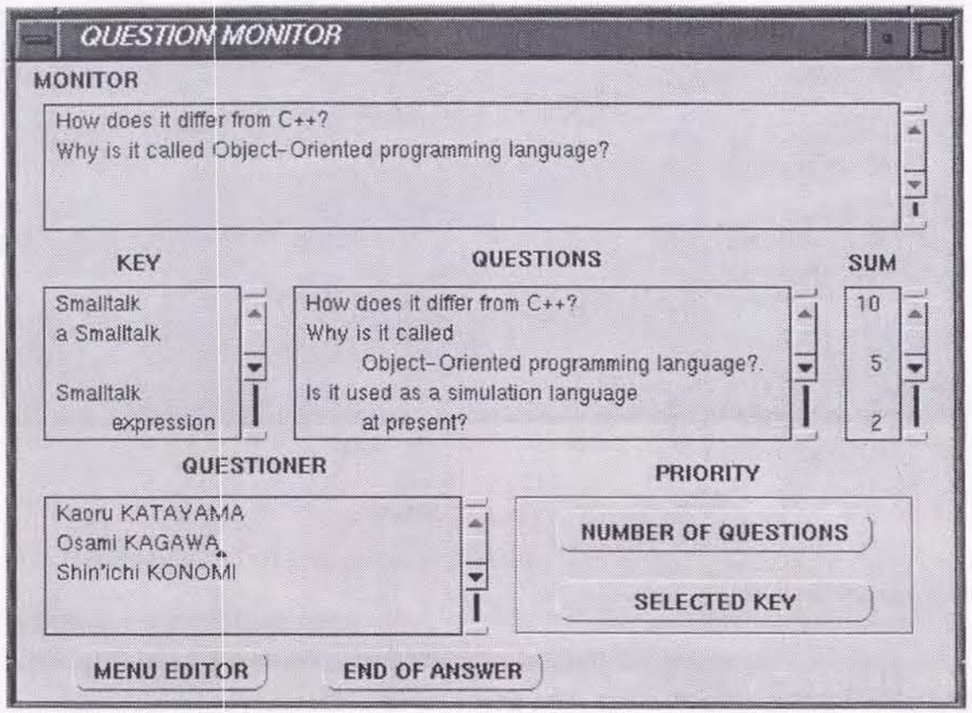

Figure 6.6 Example of the Question Display Window

overview of questions.

QUESTIONS : The texts in this field have been classified.

SUM : The number of questioners for each question are shown.

QUESTIONER : The names who posed the question.

PRIORITY : Buttons in the fields are for switching modes which KEY field is based on, namely frequency of questions base and selected key (on which teacher predefined priority) base.

MENU EDITION : This button is for calling a Editor Window to register questions to Question Menu for students.

END OF ANSWER : This button tells the system the end of answering.

Answering process is broadcast to all the students participating in the lecture like during instruction and discussion.

Standardization of teachers' tendency

Trough repeating the same lecture, teacher may find her /his best way of doing and try to fix the form on the selection of students for example. The system should offer tools to reflect the style or tendency on operation such as standard icons.

Questions and answers after class

Related to questions and answers after class must be considered. The system enables attendants after class to hear them as a part of lecture by reviewing. They can participate Q-A as long as automatically answered. However their new questions are possible to submit, however, there is no chance of next class or teacher ignored the question remained unanswered. Therefor, some treatment must be necessary, for example the remained questions are open to other students in the class for requesting answers by E-mail.

6.4 Object Structure

In this section, the objects' role and the relations are described. Figure 6.7 shows the relations between objects.

Question Object

This object generates Question Menu for student, collecting keyphrases such as character strings (word or phrase), figures, images supposed the same location (Figure 6.7 ⑦). For the requests of update or delete questions from student, this object satisfies.

Question-and-Answer Object

Question-and-Answer (Q-A) Object is composed of Question Contents Object (Figure 6.7 ④) and Answer Object (Figure 6.7 ⑤) and has attributes such as key phrases, locations of key phrases, contents of a questions, start and end time of the answers. If the system finds an answer to the question by using this object, the answer is sent to Question Object (Figure 6.7 ⑦). If not, it sends the question to Question Display Object (Figure 6.7 ⑥). Start and end time points the location of answering part in record of the lecture.

Question Display Object

It generates question list based on number of questioners or priority of weight teacher has specified previously. It broadcasts the process of question and answer to all the students in the

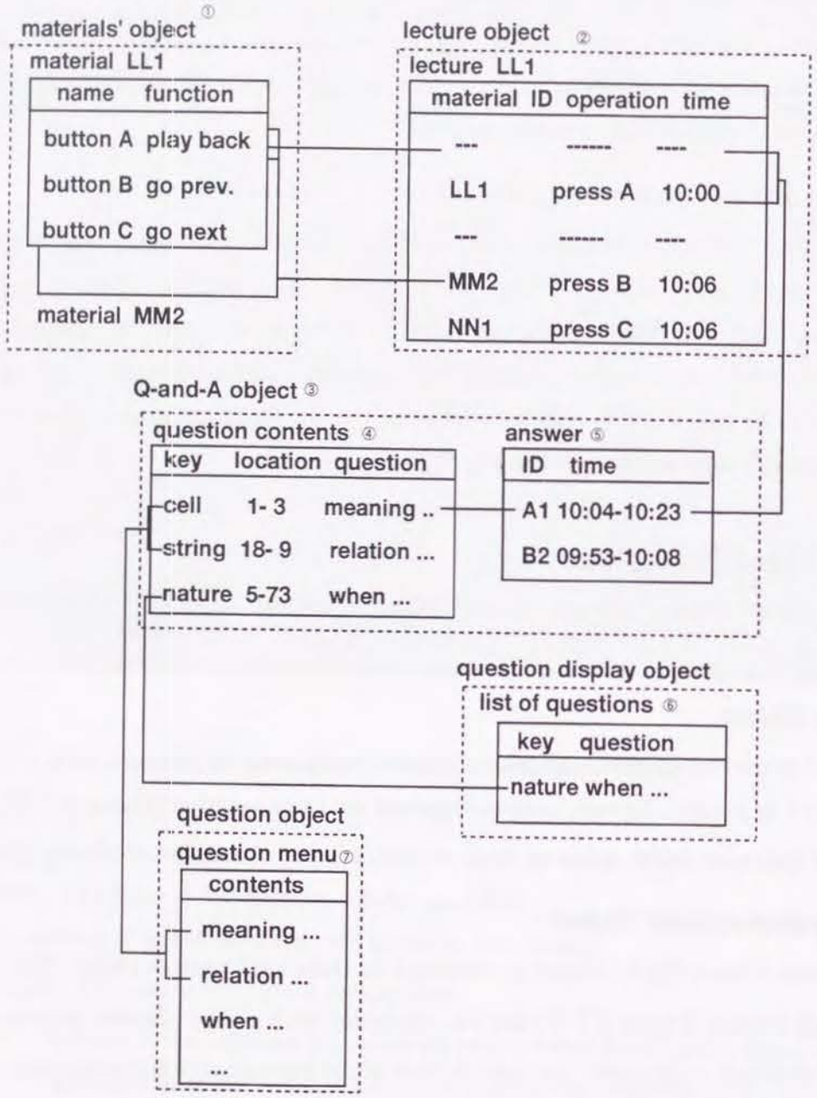

Figure 6.7 Relationships between Objects

class and also sent start and end time of answering to Q-A Object (Figure 6.7 ③).

Lecture Object

This Lecture Object (Figure 6.7 ②) has attributes such as teaching material ID, a method name of manipulate material, time when the material was sent, mouse operation and all other movies, graphics and aural conversations exchanged between teacher and student. It collects and records all actions during the lecture to make it possible to play back all or a part of them.

Material Object

Material Object (Figure 6.7 ①) is hypermedia document includes such as texts, movies, graphics and links among the materials. It functions when the lecture is recorded and reviewed, and also when additional comment is made.

Implementation Model

Figure 6.8 shows the implementation model of object in Question-and-Answer facility. Note that *VIEW Classroom* is a client-server type system.

Materials Object (Figure 6.8 ①) are sent to students using Lecture Object (teacher) (Figure 6.8 ②). The process is recorded in server. Student takes notes assisted by Note Object (Figure 6.8

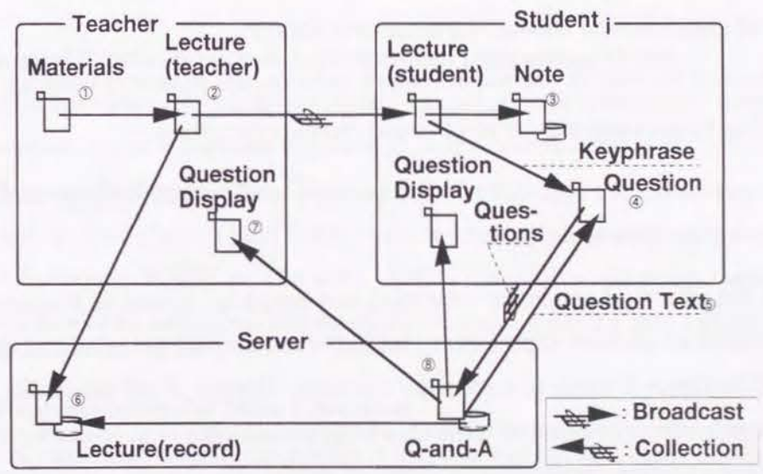

Figure 6.8 Implementation Model of Object for Question and Answer

③). When a student pose a question, Question Object (Figure 6.8 ④) collects questions (Figure 6.8 ⑤) and displayed a Question Menu. The question text student submitted is sent to the server. If it is already answered, Lecture Object (Figure 6.8 ⑥) answers. If not, the answer is sent to Question Display Object (Figure 6.8 ⑦) and displayed at teacher. In case of review, Lecture Object in server is used including answers to questions. As to the discussion after selecting a questioner, the answering process by dialogue is recorded by Lecture Object, however, the contents are managed by Q-A Object (Figure 6.8 ⑧).

6.5 Summary

This chapter presented how computer can assist for Q-A in distance education system. Interactive communication, especially synchronous communication has been requested for a long time, however, this kind of studies include highly methodological and technological difficulties especially in on-to-many style education.

The following is the specific characters of Question-Answer Facility in *VIEW Classroom*.

(1) Handling of questions and answers in One-to-Many type lecturing

(2) Specification of question formation, composing keyphrase, location and question contents

(3) Induced questions by registration questions to Question Menu or presetting on important keyphrases by teacher

(4) Reuse of questions and answers for automatic answering

(5) Broadcasting interactive communication of question and answer to audience

(6) Recording of question-answer process and contents for review

These approaches are applicable for cooperative environment systems such as presenting and conference systems as well.

Lastly, the effects of automatic answering and broadcast should be discussed again. In a lecture, students are allowed to pose questions, however, they are not submitted quite at random. Some specific topics is likely to earn much attention. Hereby, if teacher is able to catch a few high frequent question and answer to them, a large percentages of audience would be satisfied. Moreover, broadcasting the situation of question-answer would work more effectively not only for students who have related but minor question but also so passive that could not pose questions.

Chapter 7

Discussion and Future Work

Before concluding, the author wishes to discuss more on the architectures we have seen in this paper adding some ideas and addressing related considerations which shall be included in future works.

7.1 Introduction

VIEW Classroom is on the phase of design and much studies remain undone. The remainder of design at hand are: (1) test, (2) assessment of assignments, (3) class administration, and (4) system management. Besides, the system has many issues which need further discussions related with the facilities we have seen before. Among them following topics have been touched:

- **Enhancement of Synchronous and Asynchronous Interaction Model**

To find the effectiveness of synchronous and asynchronous interaction model in other interactive situation, some significant approach should be considered.

- **Question-Answer Facility in After Class**

Communication in after class is held mostly asynchronous. In many cases local tool like telephone, FAX, E-mail, WWW will be used. VIEW Classroom integrates those media and works as a coordinator by arranging communication space, selecting and calling for relevant members.

- **Symbolic Representation for Mass Education**

In this paper the number of student this system is taken in was not specified. Should the system behave differently depending on the number of student ?

• **Pedagogy for Higher Education**

If this system could provide an unique pedagogical assistance differs from existing learning systems, what will it be like ?

• **Intellectual, Phycological, Cultural Distance**

From the nature of distance education, students have widely different backgrounds and life styles. Is it possible for the system to present comfortable learning environment?

7.2 Enhancement of Synchronous and Asynchronous Interaction Model

Synchronous and asynchronous model characterizes *VIEW Classroom* as addressed in Chapter 3. At first, the necessity of the model was in question since it was not so clear which action is synchronous or asynchronous. There was no conclusion in the discussion since this issue seems to be related to individual abilities and features of subject, however, it might be more reasonable that to find significant roll of the model than to specify the distinction of the two. The following is the point of discussion :

- Synchronous and asynchronous interaction model is a model which behaves expected actions. If a student has taken an unmatched action, there is possibility that the student is isolated from the teacher and the system.
- Student should be able to catch the teachers intention toward students. Since attention is not sustained so long, students easily incline toward asynchronous actions, If teacher submits a signal to attract students attention when she/he start to give important announcement, it might be significant that system arrives at a student in asynchronous and take her/him back to the class.
- If student recognizes the unmatched with teachers instruction, she/he should be able to get retrieve the time in some way.
- Teacher should be able to recognize the unmatched level of the class. If there are many unmatched student, teacher should take a break a little while and wait them to catch up with.
- Different from a physical classroom student at home is likely to be interrupted by telephone calls or works in urgent. While a student is engaged in such asynchronous actions, instruction is proceeding steadily and as the results the student may has omitted the lecture partly. The system should catch the transition to asynchronous situation and inform the part of to recover when she/he has returned to synchronous situation again.
- As to complement of lecture, the student should be provided a few selections. One is to take no notice the lost time and another is to try to catch up with the instruction by tracing the documents. If the lost time is comparatively long, to abandon the part in class and recover it after class mighty be possible. Problem is that if the lost time is quite long and the student tries to recover it in class, she/he falls another asynchronous situation.

7.3 Question-Answer Facility in After Class

The playback-lecture presents troublesome yet interesting phenomenon between learning context and system recognition to time since the lecture has finished and system have the lecture record. After class students once go back to the past and trace back to the present. System must prepare different type of functions and messages those are never applied in normal class

View Classroom might present after-class type classrooms from the beginning. In that case, to make the class so real, lecture is held as scheduled and attended by a teacher only to answer questions. Further more to learn in short time some idea have presented like : digested lecture like speedy rewind, retrieved and edited lecture by specified key words, lecture only by aural and others. For this distance education system, time is essential resource.

7.4 Symbolic Representation for Mass Education

Teacher has several way of recognition depending on the number of student. Empirically teacher uses deferent ways of recognition for a class of (1) dozen, (2) 30-60, (3) more than a hundred or (4) hundreds. In the class of (1), students are recognized as individuals. In the class of (2), recognition of group slightly excels to that of individual. In case of (3) student is beyond individuality but only a member of group. At the class of (4) teacher recognize them only as a group. This is also true for a student to recognize other students in the same way. Through the experience of physical classrooms it might be supposed that the teachers recognition through symbolic representation become different depend on the number of students also. The representation of the changing reflected from student status should be discussed as (3) and (4) class.

7.5 Pedagogy for Higher Education

Based on Bloom's Taxonomy [Blo56], content as intellectual abilities and skills can be modelled in six levels: (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. For example, a topic such as operating systems can be viewed initially from a low user view, then at a higher level from an analytic view, and higher yet from a design or synthesis view. Generally (1) and (2) is supported by many education systems, however the assistance by computer for the rest of them are more important for higher education. *View Classroom* aims to support the learner-oriented style also so as to any student can make presentation as a teacher.

7.6 Intellectual, Phycological, Cultural Distance

Like traditional classrooms, there exists intellectual or skill gap among students. Through the authors experiences, teachers who use new media are tend to make haste in presentation. Some students are surely delayed for taking notes or submitting questions. The system should inform a teacher the situation of delay and ask to wait for a while.

Phycological distance is feeling of isolation from other users. In case of that a teacher is unconscious with students, the system should behave consciously instead of her/him to some extent, or student interest is easily lost. Some professionals addressed the necessity of introducing games to school subject.

Currently awareness is an one of the essential subjects for distance education system. However, persons especially adults of high motivation are not always satisfied with superficial concerns. So, more active and phycological approaches should be adopted based on the users behaviors. For example, periodically a system could evaluates a student activities (e.g. showing her/his frequency of notations, questions, replies as well as other students averages). The competitors may another system's partners and entertainers.

According that distance education becomes global, diversity of users leads the system face to the cultural difference in teaching and learning . Some design of *VIEW Classroom* could be redundant, meaningless, or bothering for some teachers or students in other culture zones. (Language is also another big problem, however, this system does not reach to such practical phase) Any system which accept people from world wide the design should be examined by educational professionals or other users abroad. That's the specific character of world wide distance education system.

Chapter 8

Chapter 8

Conclusion

This thesis has specified requirements for distance education systems and presented some system architectures of *VIEW Classroom* based on synchronous and asynchronous interaction model which characterizes the specific features of this system. As fundamental framework, following facilities are supported for: (1) presentation, (2) notation, (3) symbolic representation, (4) synchronous and asynchronous interaction, and (5) question and answer.

To realize effective educational environment for distance learners, the system is expected to support whole process of teaching and learning activities including above. To illustrate those interactive processes, the synchronous and asynchronous interaction model has played very significant rolls to specify functions needed and also it was found that it has high possibility for applying to other interactive situations in a class. If symbolic data representation could be integrated with video technology, asynchronous communication would be more effective and recognition between teacher/student and also between student/student would be more realistic.

At the ending of this thesis, the major results of this study are summarized as follows:

(1) Study of requirements for distance education systems

Requirements have examined in four groups as: (a) Teaching and Learning Style, (b) Teaching Materials and Notes, (c) Communication, and (d) User Interface. Most of all, communication has been the central topic in this study since great disadvantage of general distance education is the lack of synchronous interaction as many educators indicate.

To realize interactive communication among distributed students and a teacher, the system should provide not only communication medium but also prepare total communication environment including facilities to support recognition and awareness, response collection and the representation and others. Other three requirement groups were too closely

related to give solutions or describe independently and it was almost impossible to consider without addressing communication facility.

Educational activities are not completed in a classroom, mostly continued to self-learning after class. Besides, in this education setting considerably many students are supposed to participate after class. Therefore, the system is forced to preserve learning environments close to real-time class. After class communication shall be another target of future work.

(2) Specification of the nature of one-to-many interaction

Through the study of one-to-many interaction, some significant nature of this formation has been found. Firstly, it gave birth to synchronous and asynchronous interaction model to specify the complicate interaction of teacher and students. Secondly, the problems actually exist in "many-to-one" directed communication. That is, great many transactions rush for one teacher at the same time in some cases. To avoid this heavy concentrations some countermeasures was provided (see section 3.5). Thirdly, since this formation is similar to traditional classroom, the facilities for supporting one-to-many are applicable to such computerised classroom. Lastly, quality of information is questioned more than before. The data sent from teacher is out of problem, however, data from students are possibly included kind of junk. Therefore, some filtering methods are necessary depending on the objectives of collecting transactions. As to student response transactions, phycological verification to judge the effectiveness might be needed.

(3) The use of advanced database and CSCW technology

Utilizing advanced database and CSCW technology, their extended usage was examined. Those specified document structure with links is applied to teaching materials and notebook, and brought flexibility in teaching and learning environment like "media sharing"," personalization of view", "link independent from contents", "virtual update". The paper shows an effectiveness of cooperative hypermedia called *VIEW Media* which has extended the model of hypermedia to be applied for *VIEW Classroom.*

(4) Proposition of functions and structure of a distance education system

The paper has proposed fundamental structures and facilities to support distance education system. Document structure based on cooperative hypermedia and distributed system structure to reduce traffic concentration and other system load was presented. This system presented the issues and possible solutions for realizing real-time education in geographic and time distance environment.

To proceed this research hereafter, breakdown of the function structure of *VIEW Classroom* and continual study to solve technical and educational issues should maintained further more.

What the author have recognized most at present stage is the consideration toward the " limitations of computer support". In supporting teaching and learning activities in general as well as those for distance education, there exist technological limitations and pedagogical limitations. For example, it is impossible or almost nonsense for a teacher to confirm a distance student eligible and insist that student in test should not refer any study materials. Also, however rich and visual information of students responses were presented to a teacher, if the teacher is unconcern about such kind of data and never make use if it for feed back to students due to no or less recognition to the necessity and effectiveness, the services are almost in vain. Those are the examples of technical or pedagogical limitations that distance education system has. However, the elucidation about such limitations makes the roll of computer-assisted distance education system more clearly and also bring valuable suggestions to new systems in next generation.

The author believes that there exist psychological distance and cultural distance between teacher and students behind the problems mentioned above, however, I do hope that the study on distance education could contribute to give good solutions to those issues in the long run.

Bibliography

[AC96] Amow, D. M. ,Clark, D. , " Extending the Conversation: Integrating E-mail and Web Technology in CS Programming Classes," ACM SIGCSE, SIGCSE Bulletin, Vol. 28, Special Issue, pp.93-95, 1996.

[AGZ96] Apostolopoulos, N. ,Geukes, A. and Zimmermann, S. , "DIALECT: Digital Interactive Lectures in Higher Education," Proc. ED-TELCOM '96 Conf. , pp. 11-18, Jun. 1996.

[BCLNS94] Berners-Lee, T. , Cailliau, R. , Loutonen, A. , Nielsen, H. F. and Secret, A. , "The World-Wide-Web," Communications of the ACM, Vol. 37, No. 8, pp. 76 - 82, Aug. 1994.

[BS91] Boyed-Barrett, O. and Scanlon, E. ,"Computers and Learning," Addison-Wesley, 1991.

[CH96] Cornelius, S. and Heywood, I. , "The Learning Station: An interactive Learning Environment Distance Learners in Geographical Information Systems," Proc. ED-TELCOM '96 Conf. , pp. 74-79, Jun. 1996.

[Cha91] Champine, G.A. , "A Model for Distributed Campus Computing," MIT Project Athena, Digital Press, 1991.

[DBe92] Dourish, P. and Bellotti, V. , " Awareness and Coordination in Shared Workspaces," Proc. ACM 1992 Conf. Computer Supported Cooperative Work (CSCW'92), pp. 107-114, Oct. 1992.

[DBl92] Dourish, P. and Bly, S. , "Portholes: Supporting Awareness in a Distributed Work Group," Proc. Conf. Computer Human Interaction (CHI '92), pp. 541-547, May 1992.

[FBDKGLPG94] Fowler, J. , Baker, D.G. , Dargahi, R. , Kouramajian, Gilson, V. H. , Long, K. B. , Petermann, C. , Gorry, G. A. , "Experience with the Virtual Notebook System: Abstraction in Hypertext," Proc. CSCW'94 Conf. pp. 33-143, 1994.

[FF96] Fowler, W. A. L. and Fowler, R. H. , "Networks, Workstations, Multimedia, and Electronic Communities: Creating a University Learning Environment," Proc. ED-TELCOM '96 Conf. , pp. 103-108, Jun. 1996.

[Gam96] Gammerman, A. , "Computational Learning and Probabilistic Reasoning," Chichester: John Wiley & Sons, 1996.

[GHMS94] Grønbæk, K. , Hem, J. A. , Madsen,O. L. and Sloth, L , "Cooperative Hypermedia Systems: A Dexter-Based Architecture," Communications of the ACM, Vol. 37, No. 2, pp.64-75, Feb. 1994.

[Gil96] Gilbert, S. ,"The Web as a Student Communication Medium: What's Different ?," Proc. ED-TELCOM '96 Conf. , pp. 115-120, Jun. 1996.

[GO96] German, C. and O'Neill-Jones, P. , " Integration of Multimedia and the World Wide Web for Use in Distance Education," Proc. ED-TELCOM '96 Conf. , p. 361, Jun. 1996.

[GT94] Grønbæk, K. ,Trigg, R. H. ,"hyper MEDIA System Design Applying the Dexter Model," Communications of the ACM, Vol. 37, No. 2, pp. 26-29, Feb. 1994.

[HBR94] Hardman, L. , Bulterman, D. C. A. and Rossum, G. V. , " The Amsterdam Hypermedia Model: Adding Time and Context to the Dexter Model, Communications of the ACM, Vol.37, No. 2, pp. 50-63, Feb. 1994.

[HMW94] Haake, J. M. , Marshall, C. and Wiil, U. K. , "Open Issues in Collaborative Hypermedia Systems," Proc. CSCW'94 Workshop Collaborative Hypermedia Systems, pp. 5 - 11, Oct. 1994.

[HY94] Honiden, S. and Yamashiro, A. ,"Object-Oriented System Development," Nikkei BP, 1994.

[HW92] Haake, J. and Wilson, B. , "Supporting Collaborative Writing of Hyperdocuments in SEPIA," Proc. ACM 1992 Conf. Computer Supported Cooperative Work (CSCW'92), pp. 138-146, Nov. 1992.

[IMR94] Isaacs, E. A. , Morris, T. and Rodriguez, T. K. , "A Forum for Supporting Interactive Presentations to Distributed Audiences," Proc. ACM 1994 Conf. on Computer Supported Cooperative Work (CSCW'94), pp. 405-416, Oct. 1994.

[IT94] Isaacs, E. A. and Tang, J. C. , "What Video Can and Cannot Do for Collaboration: A Case Study," Multimedia Systems, Vol. 2, No. 2, pp. 63-73, 1994.

[JM96] Jamieson, P. and Martin, E. , "Understanding Teaching in the Video Conferencing Classroom," Proc. ED-TELCOM '96 Conf. , p. 143, Jun. 1996.

[Jon96] Jones, D. ,"Computing by Distance Education: problems and solutions," ACM SIGCSE, SIGCSE Bulltin, Volume 28, Special Issue, pp. 139-146, 1996.

[Kee86] Keegan, D. , "The Foundation of Distance Education," Croom Helm, 1986.

[Kon95] Konomi, S. ,"Studies on Data Management for Collaborative Systems," Diss. ,Kyoto University, 1995.

[Mur96] Mur, T. , "From Story to Knowledge Bases: The First Paradigm Shift in Making CAI "intelligent"," Proc. ED-MEDIA '96 Conf. , pp. 509-514, Jun. 1996.

[Naj96] Najjar, l.j. , "Multimedia Information and Learning," Journal of Educational Multimedia and Hypermedia," Vol. 5, No. 2, pp. 129-150, 1996.

[Nip89] Nipper, S. ,"Third generation distance learning and computer conferencing," in Mindweave: Communication, Computers and Distance Education, Mason R. and Kaye A.(eds), Pergamon Press, 1989.

[OGD94] O'Neil, D. K. , Gomez, L. M., Ddelson, D. C. , "Collaborative Hypermedia for Classroom and Beyond : A Year's Experiences with the Collaboratory Notebook," Proc. CSCW'94 Workshop Collaborative Hypermedia Systems, pp. 43-45, Oct. 1994.

[PBH96] Pustisek, M. , Bester, J. and Homan, P. , "Distance Learning System for Telekom Slovenije," Proc. ED-TELCOM '96 Conf. , pp. 270-275, Jun. 1996.

[Peh96] Peha, J. M. , "The Electronic Issue Forum: A Tool for Distance Learning," SIGCUE Outlook of the ACM, Vol. 24, No. 4, pp. 24-29, Oct. 1996.

[RC96] Rosson, M. B. and Carroll, J. M. , "Scaffolded Examples for Learning Object-Oriented Design," Communications of the ACM , Vol. 39, No. 4, pp. 46-47, Apr. 1996.

[Reb96] Rebelsky, S.A. , "Improving WWW-Aided Instruction: A Report from Experience," Proc. ED-TELCOM '96 Conf., pp. 276-281. Jun. 1996.

[RS95] Reimann, P. and Spada, H. (eds.), "Learning in Humans and Machines," Pergamon, 1995.

[Sak86] Sakamoto, K. ,"Principle and Method of Educational Technology," Meiji Tosho Shinsho 16, 16th ed. ,1986. (in Japanese)

[Sak91] Sakamoto, K. ,"Educational Technology," The University of the Air, No. 52511-1-9111, 1991. (in Japanese)

[SH96] Sharp, H. and Hall P. ," A Multimedia Approach to Providing Software Project Experience for Postgraduate Students," ACM SIGCSE, SIGCSE Bulletin, Vol. 28, Special Issue, pp. 109-115, 1996.

[Siv96] Siviter, D. ,"Computer Assistance for Managing Educational Resources and Managing Collaborative Educational Process," ACM SIGCSE, SIGCSE Bulletin, Vol. 28, Special Issue, pp. 104-106, 1996.

[Sol94] Soloway, E. ,"Log on Education: Way of Seeing," Communications of the ACM,Vol. 37, No. 2, pp. 15-20, 1994.

[TCE96] Thomas, P. , Carswell, L. , Emms, J. ,"Distance Education over the Internet" ACM SIGCSE, SIGCSE Bulletin, Vol. 28, Special Issue, pp.147-149, 1996.

[TES95] Takakuwa, Y. , Endo, S. and Siratori, M. ,"Media and Education," Text of University of the Air, No. 82469-1-9511, 1995. (in Japanese)

[TN93] Tanaka, K. and Nishio, S. (eds.), "Object-Oriented Computing I," (Based on Proc. of Workshop on Object-Oriented Computing '92) , Kindai Kagakusha, 1994. (in Japanese)

[WKK96a] Winiwarter, W. , Kagawa, O. and Kambayashi, Y. , "Applying Language Engineering Techniques to the Question Support Facilities in VIENA Classroom," Proc. 7th Intl. Conf. on Database and Expert Systems Applications, Lecture Notes in Computer Science, Vol. 1134, Berlin, Springer, pp. 613-622, Sep. 1996.

[WKK96b] Winiwarter, W. , Kagawa, O. and Kambayashi, Y. , "Multimodal Natural Language Interface for Hypermedia Distance Education - the VIENA Classroom System," Proc. 4th Intl. Congress on Terminology and Knowledge Engineering (TKE'96), Frankfurt/M. , Indeks, pp. 404-413, Aug. 1996.

[WKKK96] Winiwarter, W. , Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Collaborative Hypermedia Education with the VIENA Classroom System," Proc. 1st Australasian Conf. on Computer Science Education, New York, ACM Press, pp.337-343, July 1996.

[WKK97] Winiwarter, W. , Kagawa, O., Kambayashi, Y., " VIENA Classroom - a Collaborative Educational System with an Adaptive Multimodal Interface for Question Support ," Proc. Intl. Conf. on Computational Intelligence and Multimedia Applications, Gold Coast, Australia, Feb. 1997. [to be appeared]

[WF86] Winograd, T. and Flores, F. , "Understanding Computers and Cognition," Addison-Wesley, 1986.

[WJ94] Wan, D. , Johnson, P. M. , "Computer Supported Collaborative Learning Using CLARE: the Approach and Experimental Finding," Proc. CSCW'94 Conf. , pp. 187-206, 1994.

[Woo96] Woolf, B.P. , "Intelligent Multimedia Tutoring Systems," Communications of the ACM, Vol. 39, No. 4, pp. 30-31, Apr. 1996.

[Yaz84] Yazdani, M. (ed.), "New Horizons In Educational Computing," Ellis Horwood Series: Artificial Intelligence, Halated Press, 1984.

List of Publications by the Author

Major Publications

[1] Konomi, S. , Kagawa, O. and Kambayashi, Y. , "*VIEW Media*: A Multiuser Hypermedia System for Interactive Distance Presentation", Proc. of Computer Supported Cooperative Work (CSCW '94) Workshop on Collaborative Hypermedia Systems, pp. 30-33, Oct. 1994. (in English)

[2] Konomi, S. , Kagawa, O. and Kambayashi, Y. , "Flexible Sharing Mechanisms of Hypermedia Display Using Deputy Objects," Proc. of the 5th European-Japanese Seminar Information Modelling and Knowledge Bases, pp. 1-14, Jun. 1995. (in English)

[3] Kagawa, O. , Katayama, K. , Konomi, S. and Kambayashi, Y. , "Capturing Essential Questions Using Question Support Facilities in VIEW Classroom," Proc. of the 6th Intl. Conf. and Workshop on Database and Expert Systems Applications (DEXA'95), pp. 114-123, Sep. 1995. (in English)

[4] Winiwarter, W. , Kagawa, O. and Kambayashi, Y. , "Syntactic Disambiguation by Using Categorical Parsing in DOOD Framework," Proc. of the 20th Annual German Conf. on Artificial Intelligence, Lecture Notes in Artificial Intelligence, Vol. 1137, Berlin, Springer, pp. 363-375, Sep. 1996. (in English)

[5] Winiwarter, W. , Kagawa, O. and Kambayashi, Y. , "Applying Language Engineering Techniques to the Question Support Facilities in VIENA Classroom," Proc. of the 7th Intl. Conf. on Database and Expert Systems Applications, Lecture Notes in Computer Science, Vol. 1134, Berlin, Springer, pp. 613-622, Sep. 1996. (in English)

[6] Winiwarter, W. , Kagawa, O. and Kambayashi, Y. , "Multimodal Natural Language Interfaces for Hypermedia Distance Education - the VIENA Classroom System," Proc. of the 4th Intl. Congress on Terminology and Knowledge Engineering (TKE'96), Frankfurt/M. , INDEKS-Verlag, pp. 404-413, Aug. 1996. (in English)

[7] Winiwarter, W. , Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Collaborative Hypermedia Education with the VIENA Classroom System," Proc. of the 1st Australasian Conf. on Computer Science Education, New York, ACM Press, pp. 337-343, Jul. 1996. (in English)

[8] Kambayashi, Y. , Konomi, S. , Kagawa, O. , Lee, S. H. , Winiwarter, W. and Hayase, M. , "Database Support for Computer Supported Cooperative Work ," Proc. of the Intl. Symposium on the Development of Aerospace Industry and Its Educational and Research Issues for the 21st Century of Information and Space Era, Kyonggi-Do, South Korea, Oct. 1996. (in English)

[9] Kagawa, O. , Katayama, K and Kambayashi, Y. , "Selecting Essential Questions Using Question Support Facilities in a Distance Education System," The Institute of Electronics, Information and Communication Engineers (IEICE), 1997. (in Japanese) (to be appeared)

[10] Winiwarter, W. , Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Virtual Distance Education in a Collaborative Hypermedia Environment - the VIENA Classroom," Proc. of the Joint Pacific Asian Conf. on Expert Systems / Singapore Intl. Conf. on Intelligent Systems, Singapore, Feb. 1997. (in English) (to be appeared)

[11] Winiwarter, W. , Kagawa, O. , Kambayashi, Y. , " VIENA Classroom - a Collaborative Educational System with an Adaptive Multimodal Interface for Question Support," Proc. Intl. Conf. on Computational Intelligence and Multimedia Applications, Gold Coast, Australia, Feb. 1997. (in English) (to be appeared)

Memoirs

[1] Kagawa, O. , "Integrating Multimedia and Network to Education System," Proc. of Symposium, Information Processing Society of Japan (IPSJ), Vol. 87, No. 1, p 189, Jun. 1987. (in Japanese)

[2] Kagawa, O. , "Multimedia and LAN based Education System - Overview of the Audio Visual Room in our College -," Research Reports, Hiroshima Denki Institute of Technology, Vol. 20, Dec. 1987. (in Japanese)

[3] Kagawa, O. , "Audio-Visual Instruction System Assisted by Local Area Computer Network," Journal of Japanese society for Engineering Education (JSEE), Vol. 36, pp. 34-35, Jul. 1988. (in Japanese)

[4] Kagawa, O. , "A Study of Multiple Media Information System for Education," Journal of Japan Society of Education Information, Vol. 5, No. 4, pp. 10-16, Jan. 1990. (in Japanese)

[5] Kagawa, O. , "Effects of Audio-Visual Instruction System," Journal of Japanese society for Engineering Education (JSEE), Vol. 38, p 23, May 1990. (in Japanese)

[6] Kagawa, O. , Konomi, S. and Kambayashi, Y. ,"Design of VIEW Classroom: A System for Distance Education" Proc. of the 4th Joint Conf. on Educational Technology (JCET'94) , A13-2, pp. 30-33, Oct. 1994. (in Japanese)

[7] Konomi, S. , Kagawa, O. ,Tagato, Y. and Kambayashi, Y. , "Design of VIEW Media: A Distributed Shared Hypermedia Supporting Interactive Distance Lectures" Proc. of the 4th Joint Conf. on Educational Technology (JCET'94) ,Vol. 1, H31-3, pp. 301-304, Oct. 1994. (in Japanese)

[8] Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Design of VIEW Classroom: A System for Distance Education," Research Reports on Distance Education System using Network, Educational Center for Information Processing, Integrated Media Environment Experimental Lab. , Kyoto University, pp. 45-53, Nov. 1994. (in English)

Technical Reports

[1] Konomi, S. , Kagawa, O. and Kambayashi, Y. , "Design of *VIEW Media*: A Multiuser Hypermedia System for Interactive Presentation," Report of Technical Group on Data Eng. , The Institute of Electronics, Information and Communication Engineers (IEICE), DE94-44, pp. 1-8, Sep. 1994. (in Japanese)

[2] Kambayashi, Y. , Konomi, S. and Kagawa, O. , "Management of Related Objects in Distributed Shared Hyper-Media *VIEW Media*," Groupware '94 Symposium, Nov. 1994. (in Japanese)

[3] Katayama, K. , Konomi, S. , Kagawa, O. and Kambayashi, Y. , "Supporting Integration Between a Teacher and Students in VIEW Classroom," Special Interest Group Notes, Information Processing Society of Japan (IPSJ), 95-DBS-101-2, Mar. 1995. (in Japanese)

[4] Kagawa, O. , Masui, H. and Miyoshi, K. ,"Communication Systems for Distance Education System; VIEW Classroom," Special Interest Group Notes, IPSJ, 96-CE-39-1, pp. 1-8, Jan. 1996. (in Japanese)

[5] Kagawa, O. and Kambayashi, Y. , "Use of Symbolic Representations for Student Status in Distance Education System : VIEW Classroom," Special Interest Group Notes, IPSJ, 96-GW-17, pp. 43-48, Apr. 1996. (in Japanese)

[6] Kagawa, O. , Kamiya, Y. , Imai, H. and Kambayashi, Y. , " Q-and-A Support in a Distance Education System," Special Interest Group Notes, IPSJ, 96-GW-17, pp. 49-54, Apr. 1996. (in Japanese)

[7] Kagawa, O. and Kambayashi, Y. , "Response Collection Facilities Utilizing Cooperative Hypermedia in Distance Education System: VIEW Classroom," Special Interest Group Notes, IPSJ, 96-CE-17, pp. 1-8, May 1996. (in Japanese)

[8] Kagawa, O. , Imai, H. , Kamiya, Y. and Kambayashi, Y. , " Query Answering Support for Distance Education System:VIEW Classroom," Special Interest Group Notes, IPSJ, 96-CE-

17, pp. 9-16, May 1996. (in Japanese)

[9] Konomi, S. , Kagawa, O. and Kambayashi, Y. , "Flexible Sharing Mechanisms of Hypermedia Display Using Deputy Objects," Information Modelling and Knowledge Bases VII, Tanaka, Y. , Kangassalo, H. , Jaakkola, H, Yamamoto, A. (Eds.), IOS Press, pp. 213-226, 1996. (in English)

[10] Kagawa, O. and Kambayashi, Y. , "Response Collection Facilities Utilizing Cooperative Hypermedia in Distance Education System: VIEW Classroom," Proc. of MIS/IN/OFS Joint Reserch, The Institute of Electronics, Information and Communication Engineers (IEICE), pp. 105-112, Aug. 1996. (in Japanese)

Oral Presentations

[1] Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Design of *VIEW Classroom*: A Distance Education System Utilizing Distributed Hypermedia," Proc. of the 4th Joint Conf. Educational Tech. , Vol. 1, pp. 135-138, Oct. 1994. (in Japanese)

[2] Konomi, S. , Kagawa, O. , Tagato, H. and Kambayashi, Y. , "Design of *VIEW Media*: A Distributed Shared Hypermedia Supporting Interactive Distance Lectures," Proc. of the 4th Joint Conf. Educational Tech. , Vol. 1, pp. 301-304, Oct. 1994. (in Japanese)

[3] Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Lecture Functions in a Distance Education System Utilizing Cooperative Hypermedia," Proc. of the 50th Annual Convention, IPSJ, 3M-4, Mar. 1995. (in Japanese)

[4] Katayama, K. , Kagawa, O. , Konomi, S. and Kambayashi, Y. ,"Interaction Support for a Teacher and Students in a Distance Education System," Proc. of the 50th Annual Convention, IPSJ, 3M-6, Mar. 1995. (in Japanese)

[5] Konomi, S. , Kagawa, O. and Kambayashi, Y. ,"Presentation Support for People Distributed in Time Utilizing Cooperative Hypermedia System *VIEW Media*," Proc. of the 50th Annual Convention, IPSJ, 7M-5, Mar. 1995. (in Japanese)

[6] Kagawa, O. , Konomi, S. and Kambayashi, Y. , "Response Acquisition Facilities in a Distance Education Systems Utilizing Cooperative Hypermedia," Proc. of the 51th Annual Convention, IPSJ, 5F-5, Sep. 1995. (in Japanese)

[7] Kagawa, O. , Kamiya, Y. , Imai, H. and Kambayashi, Y. , "Basic Interaction Facilities and Their Applications in Distance Education System :VIEW Classroom," Proc. of the 52th Annual Convention, IPSJ, Mar. 1996. (in Japanese)

[8] Kagawa, O. and Kambayashi, Y. , "The Use of Symbolic Representations for Student Status in Distance Education System : VIEW Classroom," World Conf. on Educational Multimedia and Hypermedia & World Conf. on Educational Telecommunications (ED-

MEDIA/ED-TELECOM'96), Boston, U.S.A. , Jun. 1996. (in English)

[9] Kagawa, O. , Katayama, K. , Kamiya, Y. and Kambayashi, Y. , "Design of Educational Materials in Distance Education System :VIEW Classroom," Proc. of the 53th Annual Convention, IPSJ, 4K-02, pp. 267-268, Sep. 1996. (in Japanese)

[10] Kagawa, O. , Kamitani, Y. , Katayama, K. , Imai, Y. and Kambayashi, Y. , "Off-line Query-Answer Support for Distance Education System VIEW Classroom," Proc. of the 53th Annual Convention, IPSJ, pp. 269-270, Sep. 1996. (in Japanese)

[11] Kagawa, O. and Kambayashi, Y. , "Advanced Database Functions for Distance Education System : VIEW Classroom," the 2nd Conf. of Scientific Research on Priority Areas Research and Development of Advanced Database Systems for Integration of Media and User Environments (Research Project on Advanced Databases), Sep. 1996. (in Japanese)

[12] Kagawa, O. , Katayama, K. , Kamiya, Y. and Kambayashi, Y. ," Synchronous and Asynchronous Interaction Model in Distance Education System :VIEW Classroom," Proc. of the 54th Annual Convention, IPSJ, Mar. 1996. (in Japanese) (to be appeared)

Miscellaneous

[1] Kagawa, O. , "Development of Computer Network Education System," Serial of Office Area Network, UNIX USER, No. 5-8, Softbank, 1992. (in Japanese)